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ABSTRACT

Using the Cluster Analytic Model (CAM), two samples of graduating seniors from Georgia State University were studied to determine the effect of different patterns of college course work on their general learned abilities. The CAM uses Student Achievement Test scores, Graduate Record Examination scores, and transcripts for course work patterns. Growth in learning displayed in the test score results suggested that the sample students showed improvement in learning in analytic reasoning, reading comprehension, and quantitative comparisons. In the analysis of courses taken by five or more students, these three item-types explained large proportions of the score variance. Taking different course work produced different effects in general learned abilities, and those effects varied among the students of the two classes. Results also indicate: (1) that the CAM provides useful information to colleges about the mix of assessment measures that reflect what the students learn and what the college intends to teach them; (2) that it can assist at schools with a distributional general education requirement in assessment of their core curriculum; and (3) that it can, with computer linkages, help with student advising. The report includes a description of the research design for the model and a bibliography of over 200 items. (JB)

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Development & Testing of the Cluster-Analytic Model to Identify Coursework Patterns Associated with General Learned Abilities of College Students: Georgia State Native Report on Combined Samples

October 1991

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National Center on Postsecondary Teaching, Learning & Assessment
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The perspectives and conclusions are those of the authors and do not represent the views or policy of the U.S. Department of Education.

Development and Testing of a Cluster-Analytic Model

for Identifying Coursework Patterns

Associated with General Learned Abilities of College Students:

Report on Georgia State Native Combined Samples #1 & #2

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EXECUTIVE SUMMARY

THE DIFFERENTIAL COURSEWORK PATTERNS PROJECT

AND THE DEVELOPMENT OF THE CLUSTER ANALYTIC MODEL

The Differential Coursework Patterns (DCP) Project began in 1986 under Contract No. OERI-R-86-0016 from the U.S. Department of Education and continues as a part of the research program in curriculum of the National Center for Postsecondary Teaching, Learning and Assessment.

The purpose of the "Differential Coursework Patterns (DCP) Project" was to determine the effect of different patterns of college coursework on the general learned abilities of students. To accomplish this end, a model for linking what coursework students took in college with what they learned in college was developed. The result was the Cluster Analytic Model. The Model groups courses appearing on student transcripts according to the distribution of assessment scores of those students. The Model uses precollege indicators of student learning to control for incoming student ability. It uses transcripts, rather than formal course or degree requirements as the representation of the college curriculum. The Model can use any number of assessment measures, including both quantitative and qualitative data.

Over the past five years, the DCP Project team has developed and tested the Cluster Analytic Model in a variety of college and university settings. Consistently, the Model has identified and correctly classified approximately 8 of every 10 courses undergraduates took according to the multiple measures of student learning used. To date, the Model has employed such criterion measures as the 9 item-types of the GRE General Test, Kolb's Learning Styles Inventory, a locally-developed instrument measuring the students' perception of the difficulty of the courses, and the ACT COMP examination subscores. Discriminant analyses of the course groupings according to these measures indicated an average correct classification rate of over 80 percent.

Summary of the Cluster Analytic Model. The basic steps in the DCP cluster analytic model are summarized as follows. For simplicity of example, SAT scores were used as measures of incoming student ability. GRE item-type scores were used as measures of general learning. Coursework patterns were derived from the transcripts of graduating seniors at each of six postsecondary institutions. First, student achievement was determined by removing the predicted effect of SAT sub-scores on GRE item-type scores; the 9 item-type residuals served as 9 criterion variables of general learned ability during the student's baccalaureate years. Second, the mean residual scores of students enrolling in each course were determined and attributed to that course. Third, courses were taxonomized (or grouped into patterns) using one of two cluster analysis procedures according to the 9 GRE residual scores of the students. Fourth, the secondary validity of the clusters and the contribution of each of the 9 item-type residuals to the clusters were established by discriminant analysis. Fifth, the resulting patterns were described in terms of the combinations and sequences in which the students enrolled in them and the predominant curriculum characteristics of the courses in the resulting pattern. Lastly, the coursework patterns were examined to determine the extent to which they were associated with a discipline or set of disciplines and the general education requirements of the college or university.

Following these procedures produced a set of **hypothesized** relationships between coursework patterns and measures of general learned abilities. To provide primary validation of these relationships, a second sample of graduating seniors was drawn from each participating institution, and the procedures of the cluster analytic model were repeated to determine the extent to which the coursework patterns and their relationship with the criterion measures of general learned ability were replicated.

The conceptual framework for the cluster analytic model was initially derived from a review of selected literature. This review revealed that no one curricular model and no one analytical process clearly identified the effect of differential coursework on general learned abilities. Development and testing of an analytic model for studying the differential effect of coursework in a complex curricular organization was required. A conceptual-empirical approach was adopted for the examination of the research problem, wherein a conceptual framework of student course decisions and selections guided the empirical search for coursework patterns associated with gains in general learned abilities.

The results of prior studies of DCP student samples revealed substantial year-to-year variation in what students took (the coursework on their transcripts) and what they learned (the residual gains in student learning on the nine item-types of the GRE). Review of the data revealed that a substantial number of courses taken by the first sample were also taken by the second sample. The analysis of combined samples permits the further identification of coursework patterns beneficial to both groups while minimizing year-to-year variation in test scores. Given that the objects of analyses were courses and not students, scores from two consecutive student groups were combined for the purposes of further analysis of trends on coursework patterns.

Findings of the Research. The following is an excerpt of the findings and conclusions from the combined first and second samples of graduating seniors at one of the institutions participating in the DCP Project, Georgia State University (GSU). The sample discussed in this report consisted of native students who began and completed their education at Georgia State. A separate report (Ratcliff, 1991) presented the findings of a sample of students who began at Clayton State College and subsequently transferred and graduated from Georgia State. Another report will be forthcoming which focuses on the results of the total Georgia State sample (the combination of both native and transfer students). The two student samples were similar to the population of graduating seniors for each year in terms of SAT scores, majors and demographic characteristics. The two samples were also similar to one another. There was no significant year-to-year variation in student characteristics, nor was there major variation in the characteristics of the samples relative to the population. The samples were small and were combined to permit further analysis.

The growth in learning displayed in the test score results suggested that Georgia State Native students showed improvement in learning in Analytic Reasoning, Reading Comprehension, and Quantitative Comparisons. In the analysis of courses taken by 5 or more students, these three item-types explained large proportions of the score variance. In each of these analyses, these GRE item-types proved to explain most of the gains in student learning. Taking different coursework produces different effects in general learned abilities, and those effects varied among the students of the 1986-87 and 1987-88 classes of graduating seniors. These results suggest that beyond growth in Analytic Reasoning, Reading Comprehension, and Quantitative Comparisons, it is not meaningful to generalize about the specific effects of GSU coursework on the general learning of GSU Native students.

What does the Cluster Analytic Model tell us about assessment? The Cluster Analytic Model uses multiple measures of assessment. It provides colleges with information regarding the extent of variation in student assessment results that is explained by any one of the measures used. This information can be helpful in a number of ways. Faculty and administrators need not decide on an ideal set of assessment measures. The extent to which such measures may overlap in describing student learning can be identified. The mix of assessment measures appropriate to the goals of the college and the characteristics of the student population can be continuously monitored. When students show small amounts of growth on an indicator of student learning, either the college can develop strategies for improving student learning in the area identified, or discard the measure as inappropriate to the college and its students. The Cluster Analytic Model provides useful information to the college about the mix of assessment measures that reflects what the students learn and what the college intends to teach them.

What does the Cluster Analytic Model tell us about the curriculum? The Cluster Analytic Model is a tool ideally suited to institutions of higher education with a distributional general education requirement and a wide array of programs, electives and majors. For example, if one of the assessment measures a college selects is a test of analytic reasoning, then the Cluster Analytic Model can identify those groups of courses that students took who showed significant improvement in that area of general learning. Furthermore, the student population can be subdivided into high ability and low ability students, by gender, race or ethnicity, or by major. Then the Model can identify if the coursework associated with gains in learning among the total group is the same as that for the subgroups. Such appropriate information is valuable to curriculum planners. Courses in the general education sequence not found to be associated with gains in student learning can be revised, enhanced or dropped. Courses outside the general education requirements that contribute to gains in student learning can become candidates for inclusion in the general education curriculum. The extent to which general education courses affect the learning of both high ability and low ability students has relevance in deciding how wide ranging the distributional options should be or whether a core curriculum is appropriate for the students and the educational goals of the institution.

How can the Cluster Analytic Model help with advising students? By linking the coursework students take with their improvement in learning, the Cluster Analytic Model can be particularly valuable in advising students. First, it takes advising beyond the mere listing of formal degree requirements to the identification of those specific courses in which students of comparable interests, abilities and achievement have enrolled. Given several years of assessment data linked to the transcripts of graduating seniors, the Model may identify an array of courses taken by students who showed the largest gains in general learning in college. The Model is amenable to the development of a microcomputer-based advising system utilizing a relational database of prior students coursetaking patterns and assessment results. Such a computer-based advising system would yield an array of effective coursework tailored to the abilities and interests of individual students and within the parameters of institutional degree requirements.

INTRODUCTION

The Differential Coursework Patterns Project and the Development of a Cluster Analytic Model

The purpose of the "Differential Coursework Patterns" (DCP) Project is to determine the effects of different patterns of college coursework on the general learned abilities of undergraduate students. Student samples were drawn as volunteer samples from 5 geographically and curricularly diverse colleges and universities; each sample represented the diversity of Scholastic Aptitude Test (SAT) scores and majors of the graduating class at each institution. The precollege general learned abilities of each sample of students was controlled in the research. The effect of SAT scores on the postcollege measures of student learning were determined and partialled from the analysis; the remaining residual scores were used as criterion variables of student achievement. Thus, exiting student general learned abilities were operationally defined by the residual differences from the predicted and observed scores on 9 types of learning ("item-types") measured by the General Test of the Graduate Record Examination (GRE).

The GRE General Test consists of three sections: verbal, quantitative and analytical; within each test section are specific types of test items (i.e. Verbal: analogy items; Quantitative: quantitative comparisons; Analytic: logical reasoning). There is a total of 9 item-types within the General Test, and the 9 residual differences from the predicted and observed scores of students constituted the primary measures of exiting student achievement in general learning. Thus defined, exiting student achievement served as a metric in the analysis of the differential coursework represented in the transcripts of each institutional sample.

Six institutions of higher education participated in the original DCP project. Each institution represented a different Carnegie classification. The institutions were: Clayton State College (Morrow, GA: a public community college at the time the enrollment of the sample); Evergreen State College (Olympia, WA: public liberal arts college II); Georgia State University (Atlanta, GA: doctoral-granting university); Ithaca College (Ithaca, NY: comprehensive college); Mills College (Oakland, CA: private liberal arts I); Stanford University (Oakland, CA: private research university I).

The approach taken in the DCP project was empirical. No a priori construct or model of curriculum was used to define what constitutes a differential coursework pattern. Rather, patterns were viewed as aggregations of (a) individual courses, (b) combinations of courses taken concurrently and (c) sequences of courses taken over time. Thus, the smallest unit of analysis for a coursework pattern was a single course. For the purposes of analysis, each course examined had 9 attributes represented by the 9 residual item-type scores of students enrolling in the course. Courses with sufficient enrollment by the student sample were grouped according to the collective item-type scores of the students enrolling in the course; thus, each course examined had a mean residual gain score for each item-type.

The effect of individual courses, combinations of courses and sequences of courses on test score residuals was determined using hierarchical cluster analysis. The secondary validity of the coursework clusters (patterns) was derived and their relationship with the 9 item-type residual scores was determined by discriminant analysis. The resultant patterns were then examined in terms of their role in the formal general education structure of the institution, the dominant type of instruction represented in specific patterns, and the nature of learning represented in those courses.

The basic steps in the DCP cluster analytic model were as follows. Coursework patterns were derived from the transcripts of graduating seniors at each of six postsecondary institutions. First, student achievement was determined by removing the predicted effect of SAT sub-scores on GRE item-type scores; the 9 item-type residuals served as 9 criterion variables of general learned ability during the student's baccalaureate years. Second, the mean residual scores of students enrolling in each course was determined and attributed to that course. Third, courses were taxonomized (or grouped into patterns) using one of two cluster analysis procedures according to the 9 GRE residual scores of the students. Fourth, the secondary validity of the clusters and the contribution of each of the 9 item-type residuals to the clusters were established by discriminant analysis. Fifth the resulting patterns were described in terms of the combinations and sequences in which the students enrolled in them, and the predominant curriculum and instructional characteristics of the courses in the resulting pattern. Lastly, the coursework patterns were examined to determine the extent to which they were associated with a discipline or set of disciplines, the general education requirements of the college or university, the declared majors of the students enrolled, or the major demographic descriptors of the students (i.e., gender, race, age).

Following these procedures produced a set of <u>hypothesized</u> relationships between coursework patterns and measures of general learned abilities. To provide primary validation of these relationships, a second sample of graduating seniors was drawn from each participating institution, and the procedures of the cluster analytic model were repeated to determine the extent to which the coursework patterns and their relationship with the criterion measures of general learned ability were replicated. The replication with a second student sample demonstrated significant year-to-year variation in coursework and student learning. This reanalysis of Georgia State University students attempts to identify common trends in learning and coursework between the two years.

The conceptual framework for the cluster analytic model was initially derived from a review of selected literature. This review revealed that no one curricular model and no one analytical process clearly identified the effect of differential coursework on general learned abilities. Development and testing of an analytic model for studying the differential effect of coursework in a complex curricular organization was required. A conceptual-empirical approach was adopted for the examination of the research problem, wherein a conceptual framework of student course decisions and selections guided the empirical search for coursework patterns associated with gains in general learned abilities

During the first project year (1986-87), a model was postulated to determine effects associated with differential coursework patterns on selected measures of general learned abilities of students. Requirements of this model were that it should have explanatory power regardless of institutional setting and should function independently of the particular assessment tool (i.e., the GRE exams) chosen. The generalizability of the model to other institutional settings was tested in the second year of the project. The model as initially postulated was refined using a supplemental historical data set of student transcripts and test scores from Georgia State University (GSU). The preliminary testing and analysis of the model occurred later in the first project year, when the first sample of graduating seniors at GSU (Sample Group #1) was given the GRE and LSI instruments. Results from that administration were analyzed in previous DCP Project reports (Ratcliff, 1988, 1989).

During February 1988, a random sample of graduating seniors at the other institutions participating in the study (Evergreen State, Ithaca, Mills and

Stanford) were given the GRE and LSI. Sample Group #2 at GSU was given the GRE, LSI and MPDQ in February 1989. Educational Testing Service scored the GRE tests, prepared a data tape of score results, and retired and released the test forms to the five institutions tested in May 1988 for Sample #1 and in May 1989 for Sample #2. This report combines the findings from the native students at Georgia State University as Sample Group #1 and Sample Group #2. The findings for Georgia State Sample #1 and Georgia State Sample #2 were presented in earlier reports (Ratcliff, 1988, 1989, 1990).

Organization of the Report

This report is divided into 7 sections. Each section describes a major component of the research activity. Section 1 describes the theoretical basis for the differential coursework hypothesis, the development of the cluster analytic model as a means of testing it and the research objectives of the DCP project. Section 2 provides a detailed description of the procedures and methodology used in conducting the research. The cluster analytic model is described procedurally. Section 3 portrays the major characteristics of the combined sample #1 and #2 of graduating seniors whose transcripts and test scores were examined as part of the data gathering and analysis. Section 4 describes the characteristics of the courses found on the student transcripts in terms of the criterion variables: the GRE item-type residuals. Section 5 depicts the intended curriculum of the institution, its goals, curriculum organization and structure. Section 6 reports the findings from the combined sample using the quantitative cluster analytic procedures described in Section 2. Section 7 offers a summary, conclusions and recommendations emanating from the research.

Acknowledgments

This report is the result of many people's efforts. First and foremost, Jim Prather, Director of Institutional Research at Georgia State and his associate Carol Hand, served as liaisons to the project. They arranged for the compilation of Georgia State student transcripts and explained the project to faculty and students often wary of anything involving standardized testing. Carol also coordinated the merger of test and transcript data which ultimately served as the basis for the current study.

At Educational Testing Service, Craig Mills and Susan Vitella arranged for and oversaw the special administration of the GRE and the preparation of data tapes that reported the results of the study. At Iowa State University, where DCP was first housed, Marva Ruther was project secretary, handling the many details in the development of the initial reports and analysis of data. Robert Strahan was the DCP Project team member who oversaw the actual administration of GRE testing at Georgia State. While many were involved in the production of data upon which this report is based, only the authors are responsible for the findings and conclusions reported here.

Research Design for the Model

What are "general learned abilities"

The cluster analytic model does not present nor does it rely on a particular theory of student learning. There is widespread disagreement on what constitutes "general learned abilities", and that disagreement is manifest in the variety of general education goals and degree requirements found in American higher education (Bergquist, Gould & Greenberg, 1981; Carnegie Foundation for the Advancement of Teaching, 1979; Gaff, 1983; Levine, 1978). Within the term "general learned abilities", we mean to include such frequently used terms as "higher order intellectual processes" (Pascarella, 1985), "academic competencies" (Warren, 1978), "generic competencies" (Ewens, 1979), "generic cognitive capabilities" (Woditsch, 1977), and "general academic ability" (Conrad, Trisman & Miller, 1977). Disagreement on terminology is but one aspect of the problems associated with measuring the general learning of students as undergraduates.

Current notions of how to assess college outcomes call for multiple measures of student achievement. No one measure has been found to accurately reflect the variety of definitions of general learning and cognitive development, the mixture of curricular goals and institutional characteristics found across the landscape of higher education and among the diversity of instructional procedures and curricular organizations of undergraduate higher education. The result has been a call for multiple measures of assessment of student learning. Policymakers and academic leaders tend to believe that since colleges and universities have broad missions and goals, assessments should be comparably broad enough to provide evaluation about as many institutional intents as possible (Loacker, Cromwell & O'Brien, 1986; Nettles, 1987).

Given the variety of terms, intents and theoretical frameworks used to explain "general learned abilities", the research design presented here is criterion-referenced. That is, the design is not based on any one notion of what constitutes "general learned abilities" or any one college curricular structure intended to promote student cognitive development. The design permits the use of multiple and different measures of student outcomes, although the design is being developed and tested using one set of such measures. The validity of the assessment of student learning within this research design, then, is dependent upon the validity of the outcome measures selected, rather than the degree to which the student outcomes suffice a global (goal-free) measure of student learning. The design fulfills the need for multiple measures and criterion-referenced measures of student learning. However, because the design described below is not dependent upon any given college curricular structure or organization and, in fact, will be tested in five very different higher education institutions, it is free of bias engendered by specific institutional goals.

What constitutes student achievement?

Another question encountered in determining what constitutes general learned abilities is that of what composes the gains resulting from a college education. Simply measuring how graduating seniors perform on a series of tests is not a sufficient basis for generalizations about the effect of college on student achievement. First, the assessment of student outcomes is heavily affected by the students' academic achievement prior to entering college (Astin, 1970a, 1970b; Bowen, 1977; Nickens, 1970). In fact, standardized tests used for college admission, such as the Scholastic Aptitude Test (SAT), have been shown to be strongly correlated with tests used for graduate and professional school admissions, such as the General Tests of the Graduate Record Examination (GRE). These correlations have been demonstrated for the total and sub-scores on the two tests, suggesting that a large proportion of what postcollege tests, such as the GRE, measure are attributable to student learning prior to college. Since the SAT and GRE examinations were used in the development of the DCP cluster analytic model, further examination of their capacity to measure general learned abilities follows.

Nichols (1964) studied the effects of different colleges on student ability as measured by the Graduate Record Examination's Aptitude Test. A sample of 356 National Merit finalists attending 91 colleges was used. The effects of college characteristics, major fields and types of colleges on student GRE scores were examined while controlling for the precollege student characteristics. Strong correlations existed between the students' SAT scores and the students' GRE scores which ranged from .65 for the verbal to .76 for the Quantitative. The results from this research indicated that the college students attended did have an effect on their GRE performance. There was a significant tendency for colleges to separate Verbal and Quantitative scores and raise one while lowering the other. Therefore, "the effect of college appears to be one of directing the students' abilities into verbal or quantitative channels rather than affecting the overall level of ability" (p. 52).

Rock, Centra and Linn (1970) and Rock, Baird and Linn (1972) examined SAT and GRE area test scores of 6,855 students who graduated from ninety-five colleges, predominantly small, private liberal arts institutions. The correlation between college means on SAT-Verbal and GRE-Total was 0.91. However, the colleges whose students had the same SAT means did not necessarily have similar GRE means. Rock, Baird and Linn found that "for colleges characterized by similar and relatively higher verbal input, the humanities data do suggest that proportion of faculty with the doctorate, size of budget, and selectivity are related to achievement" (p. 158).

The fact that the standardized precollege and postcollege tests, such as the SAT and GRE, are strongly correlated should not be surprising. Students typically bring 12 or more years of formal education with them upon entrance to college, and since the college years traditionally constitute 4 or 5 years, a large proportion of general learned abilities of students should be attributable to learning experiences prior to college admission.

The strong relationship between the SAT and the GRE is both an asset and a liability. The use of the SAT subscores as precollege measures and the GRE item-types as postcollege measures does provide a basis for controlling the effects of student academic achievement using comparable definitions of general learned abilities and comparable testing procedures. However, the strong correlation between the two tests leaves only a small amount of explained variance between precollege and postcollege scores to attribute to general learning associated with a baccalaureate program.

The dilemma posed by the use of the SAT and GRE as measures of general learned abilities among students is exacerbated by the student population differences upon which the tests are normed. Adelman (1985) estimated that 25%-30% of graduating seniors take the GRE General examinations, while 60% of the graduating high school students take the ACTs or SATs. These rough percentages are understandable since fewer individuals choose to continue their education from bachelor's to graduate study than do those who choose to go to college from high school. Nevertheless, a consequence is that the GREs are normed on a higher ability population than the SATs (Pascarella, 1985). The individuals taking the GREs constitute a self-selected sample, driven in part by the requirements of graduate schools, professional schools, departments offering graduate degrees, and organizations requiring such examinations as part of the formal application for fellowships and scholarships (Adelman, 1985). In the DCP Project, a concerted effort was made to have each sample of graduating seniors not limited to this self-selected group who would have taken the GRE as a normal event toward their application to graduate school. DCP Project sampling procedures is discussed in Section 3. Nevertheless, it is important to note that the Graduate Record Examination can be accurately viewed as a measure of a student's predicted performance in graduate school as well as a measure of that student's general academic accomplishments as an undergraduate.

The GRE and SAT tests have been criticized for a) the bias resulting from groups upon which they were normed (Adelman, 1985; Nettles, Thoeny & Gosman, 1986) and b) their limitation in measuring higher order reasoning skills. These criticisms notwithstanding, the GRE and SAT tests do provide an economical, practical, and valid way of measuring selected general learned abilities while controlling for the incoming academic accomplishments of freshmen (Astin, 1968; Hendel, 1977). Critics of the GRE and SAT as measures of general learned abilities attack the validity of the measures themselves. These criticisms primarily are based on the use of sub-scores and total scores of the tests. The use of either the GRE or SAT item-type scores as <u>multiple measures</u> of general learning has previously not been widely explored (Adelman, 1988). The DCP Project provided a detailed assessment of GRE item-types as discrete measures of general learned abilities.

While the GRE and SAT tests were used in the development of the DCP cluster analytic model, it is not dependent upon these sets of measures. The model can be employed using another set of correlated precollege and postcollege measures in a longitudinal analysis (for example see Pike, 1988.) For pragmatic and economic reasons, the cluster analytic model was developed using SAT and GRE tests. The model was initially developed using the two sub-tests of the SAT and GRE: the SAT Verbal Test (SAT-V), the SAT Mathematical Test (SAT-M), the GRE Verbal (GRE-V), and the GRE Quantitative (GRE-Q). Subsequent development and testing of the model employed the 9 item-type parts of the GRE as multiple measures of student learning. Therefore, the cluster analytic model will be described in terms of 9 measures of student general learned ability.

Prior research suggested that the 9 item-type scores were independent measures of general learning. Wilson (1985) examined the criterion-validity of the 9 item-type part scores of the GRE General Test to the prediction of self-reported undergraduate grade point average (GPA). For his research, Wilson used the GRE scores of 9,375 examinees in 9 different fields of study representing 437 undergraduate departments from 149 colleges and universities. Data were first standardized within each department, then pooled for analysis by field of study. Results suggested that the GRE item-type scores did differentiate undergraduate GPA by field of study. This research and other studies (Powers, Swinton & Carlson, 1977; Swinton & Powers, 1982; Wilson, 1974) indicated that the 9 item-type subparts of the GRE measure different and somewhat unique general learned abilities. Initial testing of the DCP model at four colleges and universities also indicated that the item-types constituted independent measures of general learned abilities (Ratcliff, 1988, 1989).

The GRE General Test consists of three sections: verbal, quantitative and analytical; within each test section are specific types of test items (i.e. **Verbal**: analogy item; **Quantitative**: quantitative comparisons; **Analytic**: logical reasoning). There are 9 item-types within the General Test; the residual differences between the observed GRE scores (postcollege measure) and the GRE scores predicted by the students' corresponding SAT scores (precollege measure) were used to gauge general learned abilities attributable to the students' undergraduate education. The residual differences between the observed and predicted values of each GRE item-type served as the 9 measures of student gains in general learned abilities during the time in which the student was enrolled in college. Thus in an economical and practical way, these student item-type residuals represented a set of multiple measures of general learned abilities which accounted for and controlled the effect of precollege student achievement on postcollege student outcomes.

What constitutes a coursework pattern?

The prevalent way to view the college curriculum is by its intentions, rather than by its results (Warren, 1975). Since measuring the effects of the curriculum is problematic, it is not surprising that many studies presume rather than test the effect of different patterns of coursework.

The college curriculum is substantiative, additive and temporal. In terms of cognitive theories of curriculum development, both content and process contribute to developmental learning in students (Tyler, 1950; Taba, 1962). Essentialist and constructionist theories of curriculum stress combinations of subjects (core curricula, great books, etc.) as influential on general learned abilities of college students (Fuhrmann and Grasha, 1983). The medieval university curriculum was organized according to combinations and sequences of courses as well as individual subjects (Rudolph, 1977); the seven liberal arts were sequenced into the prerequisite subjects of the quadrivium (arithmetic, geometry, astronomy, and music) and the higher order subjects, the trivium (logic, grammar, and rhetoric). Together, the quadrivium and trivium provided an individual with the general learned abilities needed to study the three philosophies of Aristotle: natural philosophy (physics), moral philosophy (ethics), and mental philosophy (metaphysics). These combinations and sequences of coursework have been generalized more recently into concepts of breadth and depth as criteria by which to describe higher education curricula (Blackburn et al., 1976).

While the notion that combinations of concurrent coursework and developmental sequences of coursework lead to effects in the general learned abilities of students is derived from the medieval university, it is underscored and further supported by the research of contemporary developmental theorists. Perry (1968) for example, stated that development "consists of an orderly progression of cognition in which more complex forms are created by the differentiation and reintegration of earlier, simpler forms" (p. 44).

The value of curricular substance and sequence are presumed in formulations of core curricula, in the four levels of study (freshman, sophomore, junior and senior years), in the corresponding practice of assigning course numbers according to those divisions, and in the practice of assigning course prerequisites. To assess the impact of these coursework patterns on the general learned abilities of students, the additive, substantiative and sequential characteristics of student course-taking need to be examined. These notions of what ought to be taught and what students ought to learn presumably represent the philosophical and educational aims of the particular college.

Nevertheless, a distinction should be made between those patterns of coursework <u>intended</u> to fulfill undergraduate program and degree requirements and those patterns of coursework which students actually choose (Boyer & Ahlgren, 1981, 1982, 1987; Warren, 1975). Intentional patterns of coursework are provided in a variety of publications issued by the institution: the college catalog, the annual schedule of times and days of courses, and program descriptions issued by departments and divisions within the college. Richardson et al.

(1982) provide evidence that a minority of students may consult these statements of curricular intent prior to making decisions about which courses to choose. Other forms of intentional coursework patterns are the lists of courses or subjects required for certification or licensure in a particular profession, occupation or technical field. Such lists of coursework may be compiled by practitioners and academics of a given discipline or profession to accredit college or university programs. Just as the curriculum of a particular college may represent the philosophy and educational aims of that institution, so too may the certification, licensure and accrediting standards articulate the intentions of state, regional, disciplinary and programmatic associations. All are intended patterns of coursework in the curriculum whose measure of effectiveness, in part, is the extent to which these patterns accomplish their aims in practice.

In a college curriculum, a single course may be the smallest unit of analysis. In assessing the impact of the curriculum on the general cognitive development of students, the course constitutes a datum in the analysis. A pattern of data is a design resulting from "the relation among a set of objects" (Romesburg, 1984, p. 278). In this case, the objects are courses. Therefore, a coursework pattern is a design resulting from relationships among courses. A cluster of courses (objects) is a set of one or more objects found to be similar to one another according to a given set of attributes. In the DCP Project, courses were grouped according to the extent of improvement (or decline) in general learning of the students enrolled. Thus, for the purposes of the DCP cluster analytic model, a cluster of courses is used to denote a pattern of coursework with an empirically derived set of relationships. Stated another way, a cluster of courses is a pattern based on the actual enrollment of a cohort of students, rather than the intended enrollment pattern of the college or university or the set of courses any one student selected. This distinction is important in order to differentiate between the consequences of the college curriculum and its intents.

<u>Sources of data for coursework patterns</u>

Arguments about what is and what is not an effective college curriculum are for the most part based on seasoned speculation, nostalgia about academic traditions, and unrealistic expectations of curricular coherence among and within the over 3,000 colleges and universities in the United States (Conrad, 1986). In most instances, the data used in describing the status of general education are derived from catalog studies and enrollment analyses. These data may not present an accurate picture of general education as it functions in students' programs.

Catalog data provide evidence of trends in offerings but ignore student behavior. Catalogs indicate which courses a student should take to fulfill degree requirements and describe the intended contents or outcomes of the courses; collectively, this compendium of courses and articulation of degree and program requirements ideally leads to the accomplishment of the educational philosophy and curricular goals of the institution. White (1979) claimed that "college catalogs generally have little to do with reality", and that "the educational ideas expressed ... are subsequently neither perceived nor accomplished" (p. 39). The ideals expressed are important, "yet when subjected to the rigorous scrutiny of time and experience, the academic promise is often not realized" (p. 39). White suggested that all collegiate programs, including general education, should be assessed in light of their original claims and promises.

Dressel and DeLisle (1969) investigated college curriculum trends using catalogs as primary sources of information. They conceded that data derived from studies like theirs must be interpreted circumspectly, asserting that:

> ...ambiguities and contradictions arise in the use of catalogs for research of curriculum practices, because what appears in the catalog as policy is in reality often left to interpretation of individual advisors and individual departments, and what is in reality required by an individual department is in reality left to interpretation of individual advisors and what is in reality required by an individual department is often not stated as policy in the catalog (p. 75).
>
> ...the limits described by departments tend to be more exacting and demanding than those stated in the institutional requirements listed by the college. Thus, a question arises as to whether each student actually has flexibility and innovation claimed in the general statements or whether the department control of the major serves as a limiting and inhibiting factor in this respect (p. 78).

Dressel and DeLisle also noted that catalogs, as sources of information about the curriculum, cannot be examined to determine the extent to which curriculum policies and statements correspond to actual course-taking practices of students. Because of ambiguities, inaccuracies, discrepancies, and omissions in wording in catalogs, the interpretation of the catalog varies significantly among both students and advisors. Also, catalogs often do not present a rationale for course requirements, nor is there a way to determine how, why, or when requirements were introduced. Likewise, there is no way of determining "whether claimed articulation of liberal with professional education and of breadth with depth has been successfully achieved" (p. 79). In sum, catalogs do not provide information about the consequences of the coursework on student learning, and therefore, are not appropriate for learning outcomes research.

Assessments of the outcomes of college have little meaning unless compared with either a normative group of students or the intended curricular goals of the institutions. Catalogs are often the most comprehensive statements of the intended substance and sequence of intended learning activities. From this standpoint, they provide a basis for comparison of college intentions with college outcomes. The DCP Project closely examined the extent to which the college catalog represented the formal curriculum students experience in college. This comparison is presented in Section 5 of this report.

While college catalogs are inadequate in describing course-taking behavior of students, enrollment figures as data sources also provide limited information. Although such figures are often used for evidence of curricular trends among undergraduates, enrollment analyses do not describe the actual course patterns of enrollees; however, they do reveal the extent to which different segments of the college population choose particular majors or general education courses (intended coursework patterns). Noting the inability of enrollment analysis to determine student reasons for course selection, Friedlander (1979) used transcript analysis to examine the effect of changes in the composition of the community college student body on humanities enrollments. Adelman, in an analysis of the Postsecondary Education Transcript Sample (PETS) of the National Longitudinal Study of the High School Class of 1972, summarized the advantages of transcripts as unobtrusive, empirical artifacts of student learning, "transcripts neither exaggerate nor forget" (1989, p. 1).

Student transcripts as a data source

Student transcripts are a rich, unobtrusive and problematic source of information about student course-taking behavior. Warren (1975) used transcripts to determine coursework patterns among college students in a study of 50 history graduates of different four-year colleges. The student course-selection patterns in history, as revealed in these transcripts, indicated that within the discipline there were at least three or four different history programs. This finding demonstrated that although students receive similar degrees, they do not necessarily have the same educational experiences. Warren's study suggested that students shape their own curricula as they exercise options in choosing courses to complete credit hour requirements. Furthermore, Warren demonstrated that transcripts could be used to discern broad curricular patterns.

Blackburn and associates (1976) used transcript analysis in their investigation of curricular change and course-taking behavior in two and four year colleges and universities between 1967 and 1974. One of the goals of the study was "to determine how students utilize elective time" (p. 20). Since some two-year transcripts did not indicate institutional requirements for both general education and the major, the researchers could not ascertain what courses were elective and which were prescribed. Consequently, the transcripts from two-year colleges were eliminated from the sample used to describe student course-taking patterns. The question of treatment of transfer students in transcript studies and college impact studies has also been a consistent methodological problem (Astin, 1970a).

Prather and associates (1976) used transcript analysis to study undergraduate grading practices at Georgia State University and investigated differences in grading patterns by major fields of study while controlling for such antecedents as scholastic aptitude, demographic background, course types, and longitudinal trends. They found that major field was strongly associated with the grades students received in courses throughout the curriculum. This research and previous grade studies supported the proposition that the various parts of the curriculum have different grading standards, arguing against the use of GPA as a proxy measure of general learned abilities in college students. The studies by Warren (1975) and Blackburn and associates (1976) used small samples of transcripts (5 percent) due to the time demanded in reading and assessing all the courses on each transcript. Prather and associates, however, used an electronic database of student transcript information to examine an institutional cohort; use of electronic databases of records enabled the researchers to examine larger samples of student records, thereby permitting analysis of larger sections of the curriculum.

Transcript analysis has been used to examine the general education component of the undergraduate curriculum as well. The dean of instruction and curriculum planning at the University of Pennsylvania used transcript analysis in an effort to determine which courses among the many listed in the college catalog were actually selected by arts and sciences graduates (Carnegie Foundation, 1979). He found that 1976 graduates of arts and science programs had selected "a core of 29 courses" (p. 97) in the curriculum. However, not all students chose the same combination of courses, and "many of the thousands of courses in the catalog that were not included in the core list were found on individual transcripts" (p. 97). This study illustrated one of the persistent problems in using transcript analysis to identify course-taking patterns: the enormous range of possibilities of course sequences generated by student choice in a large, multi-purpose university. It also suggested that, for whatever reason, there is a limited number of courses which most students select to complete the general education requirements of the undergraduate program.

Beeken (1982) used transcript analysis to examine the course-taking behavior of a sample of students in three Virginia community colleges. The purpose of the study was to determine the number and types of general education courses selected by students to meet the general education requirements of the Virginia Community College System. The study did not confirm the conclusion of the Carnegie Commission that the general education curriculum was a "disaster area", although the programs of many students did not present a balance of disciplines; students apparently minimized the number of mathematics and science courses in their program of study. Both those who completed an associate of arts degree and those who did not exceeded the minimum requirements for general education courses. The number of courses taken in different curricular areas of general education were related to enrollment status, age, and sex.

One of the largest collections of student transcripts is the Postsecondary Education Transcript Sample (PETS) on the National Longitudinal Study of the High School Class on 1972 (NLS). PETS data consisted of 22,600 students transcripts. While NLS has several precollege measures of achievement (high school grades, SAT, etc.) and the coursework selected by the students who attended college is represented, the NLS data has no available post-baccalaureate measure of general learning. Adelman (1989) used NLS/PETS and the NLS 5th Follow-Up Survey to demonstrate relationships between coursework taken in community colleges and success in attaining bachelors and advanced degrees, career aspirations and plans, and self-reported attributes of the jobs the students held 15 years after high school graduation. In this analysis, transcripts proved to be a powerful, non-obtrusive measure of the relationship between what a student planned, what they studied at college, and what the nature of their work was a decade and a half later.

In a limited number of studies, transcripts have been found to be a useful, valid and reliable source of information on student course-taking behavior. They provide evidence of the combination, sequence and performance of students in the patterns of courses in which they enroll. As archival records, transcripts are unobtrusive data. While most studies have limited their use of transcripts to a manual examination of a small sample of student records, there is evidence that such records, stored on a college or university computer, can be used to examine the course-taking behavior of a whole class, cohort or population of students. The cluster analytic model for determining the associated effects of coursework patterns on the general learned abilities of college students uses transcripts in precisely this manner. Transcripts maintained on an electronic database can be merged with student score residuals for the purposes of assessing the effects of the curriculum on student learning.

A conceptual framework for analyzing coursework patterns

The differential coursework hypothesis posits that individual courses on the student transcript contribute different levels of effect to the student's total college gain in general learned abilities (Benbow and Stanley, 1980, 1982, 1983; Pallas and Alexander, 1983). Thus, while all the courses Student X chose collectively affect X's gains in general learning, the effects of an individual course on X's transcript may vary in its contribution to such an effect.

For the purpose of analysis, the effects associated with a particular course are proxied by the residual scores of the students who enrolled in that course. A pattern of data is a design resulting from "the relation among a set of objects" (Romesburg, 1984, p. 278). In this case, the objects are courses. Therefore, a coursework pattern is defined here as a set of courses having comparable effect on one or more student score gains. The differential coursework hypothesis is rejected when no patterns are discernible among the data--when the score gains of students are uniformly attributable to enrollment in any and all courses in the curriculum. The hypothesis is affirmed when students who perform well on one or more postcollege measures tend to enroll in certain courses and not others.

At this point in the inquiry, the DCP cluster analytic model is not concerned with reasons for the effect. Rather, the next step is to identify and classify courses according to the score gains of students who enrolled in them, regardless of the factors that may have brought the students to enroll in the courses. Also, the model is not yet concerned with characteristics of the students, although those characteristics may covary with the course selection or achievement variables (Elton and Rose, 1967; Prather et al, 1976). Thus, in the examination of the effect of course patterns, there is no implication of direct causality of course patterns upon achievement (Astin, 1970a, 1970b).

There is reason to presume that the effect of a single course may vary according to what place it holds in the pattern of courses a student chooses (Prather et al., 1976). For example, if courses at a particular college are sequenced according to level (e.g., 100 level courses are intended for freshmen and 400 level courses are intended primarily for seniors), the effect of History 101, "Survey of Western Civilization", may differ for Student X who enrolls as a first term freshmen from Student Y who enrolls as a final term senior. Conversely, logic holds that the effect of History 451, "20th Century American Foreign Policy", may differ for the first term freshman and the last term senior (Rudolph, 1977; Veysey, 1973). If a course is viewed as contributing to the residual score for a particular measure of general learning, then a course's effect may vary according to its place in the student's pattern of courses. Therefore, course sequencing should be considered in the examination of course patterns (Bergquist et al., 1981).

Likewise, the effect of a particular course may be associated with the effect of other courses in which the student may be concurrently enrolled. Richardson et al. (1982) and Roueche and Snow (1977) noted that students may be advised to enroll in elementary writing or mathematics courses concurrently with other courses requiring the basic skills these elementary courses teach. Under such practices, the student may have much less chance to succeed in college. Traditionally, the combination of courses in which a student enrolls within a given term is presumed to have effect (Bergquist, et al. 1981; Rudolph, 1977; Veysey, 1973) and therefore also should be considered in the analysis of course patterns.

Thus, there is a great deal of uncertainty associated with why a particular student chooses a particular course at a particular time in his/her program of study. A poor grade in "Trigonometry" may cause Student Y to select a remedial mathematics course over "Introduction to Calculus". Student X, who received a high grade in "Trigonometry", may not enroll the following term in "Introduction to Calculus" because the time it is offered conflicts with a course Student X is required to take within his/her major. Or the Calculus course may be filled when Student X tries to enroll. Many factors shape the combination of courses a student chooses in a given term and the sequence of courses represented across terms in the transcript.

A modern research university may present 2,500 to 5,000 undergraduate courses from which a student may choose 35 to 45 courses to complete the baccalaureate degree. Each semester or quarter a student enrolls, that student selects several courses. Each term of registration represents a stage in the overall decision-making process which generates the patterns of coursework found on the student transcripts at the time of graduation. Each enrollment decision is limited and shaped by those courses in which the student has previously enrolled and the various degree requirements and prerequisites that are enforced during the registration process. At each successive decision-point, the student is progressively more immersed in the college environment, the norms and values of the student's peers, and the norms, values and expectations of the subjects the student selects to study.

The analysis of the pattern of courses a student chooses is a sequential decision-making process wherein certain conditions exist:

1. students make course selections in an environment of uncertainty about the consequences of their choices;

2. there are multiple reasons why students enroll in each course;

3. there are multiple options available to the student at each decision-point (term registration period);

4. student course selections are sequential; there are different decision-points (terms) in which parts of the coursework pattern are chosen, with prior decisions having some bearing on future decisions.

Under the conditions listed above, students may choose courses to minimize uncertainty and risk (i.e., seek what they perceive to be "easy" courses). They may also seek courses which will maximize the efficiency (i.e., fulfill degree and graduation requirements with a minimum amount of time), or maximize effectiveness (e.g., "it's a hard course, but I need to pass it if I'm going to major in engineering"). In this way, the succession of registration decisions comprising the student's pattern of coursework conceptually conforms to the multiple-stage decision analysis process (Buchanan, 1982; Bunn, 1984).

According to Pace (1979), one variable in student development is the amount of time and effort invested by the student. This premise, that student involvement in learning advances student achievement, guides the recommendations of the NIE Study Group's Report on Conditions of Excellence in American Higher Education (1984). Not only the kind and quality of cognitive activities in which the student engages, but also the level of effort exerted by the student in understanding and using the knowledge and abilities gained influence the quality of student learning. The student's effort in courses is "impressed" (Pace, 1979) by attitudes of the perceived usefulness of the course and the perceived difficulty of the course. These perceptions influence the kind and quality of student investment in learning. Coyne and Lazarus (1980) found that such investment involved both cognitive and subjective elements, leading to whether the experience is viewed as a challenge or a threat. The perceived difficulty of courses influences student enrollment decisions and thereby contributes to the multiple-stage enrollment decision-making process through which the student compiles his or her particular collection of coursework.

In summary, the literature suggests a number of possible interactions between student and curriculum each time a student makes course selections. The effect of courses on general learned abilities may vary according to the course itself, the time of enrollment in the student's baccalaureate program, the concurrent or sequential relationship to other courses in which the student enrolls, the predominant learning style of the course and of the student, the curricular design of the course, and the risk-taking behavior the student exhibits at each enrollment decision-point. The DCP cluster analytic model calls first for the identification of student achievement (i.e., student score residuals), second for the classification of courses found on student transcripts into patterns according to their associated effects on the student score residual, and thirdly, for the further classification of courses within each identified pattern according to a) sequence and combination, b) the learning styles of the students, c) the risk-taking behavior of the students, represented by their perception of the difficulty of selected courses in which they enrolled, and d) the common curricular characteristics of courses found within a given pattern of coursework. The model provides a basis for examining the extent to which the empirically-derived patterns of coursework reflect institutional mission and curricular goals, general educational requirements, the values, norms and mode of inquiry represented by the disciplines studied, and the demographic characteristics of the students. The model accomplishes these objectives through the use of cluster analysis, a statistical procedure which has been used throughout the physical and social sciences to derive empirical taxonomies of objects in a variety of settings. Cluster analysis, since it has been infrequently employed in education, is described in greater detail in Section 2.

Research objectives of the DCP Project

The objectives of the DCP Project:

1. To determine student academic achievement in general learned abilities gained during the baccalaureate program. This achievement was measured by the fixed criteria of the residual scores on the 9 item-type subparts of the General Test of the Graduate Record Examination (GRE), once the effects of precollege achievement as measured by Scholastic Aptitude Test (SAT) scores were removed.

2. To classify the coursework taken during a student's baccalaureate program according to its associated effects on the student's general learned abilities, as measured by the GRE. This coursework was determined by a cluster analysis of student transcripts wherein courses will be described and classified into patterns according to the GRE residuals of the students enrolling in them.

3. To test the secondary validity of the coursework clusters and to identify outlying cases within each cluster of courses, discriminant analysis was applied to the results of the cluster analysis. Through examination of pooled within-group correlations of discriminant functions with GRE item-types and the cluster group means on each discriminant function, relationships between cluster groups and item-type residual scores was determined.

4. To describe the resulting patterns of coursework according to:

   a. sequences and combinations of courses within the cluster, according to term of enrollment data found on student transcripts;

   b. learning styles of the students enrolling;

   c. common curricular characteristics;

   d. perceived difficulty of the coursework.

5. To determine the extent to which the resulting patterns of coursework are associated with:

   a. type of college or university;

   b. type of institutional general education degree requirements;

c. type of academic discipline or field of study;

d. student demographic characteristics.

<u>Samples used in the initial development of the cluster analytic model</u>

For the purposes of building and testing the cluster analytic model, an historical database was developed at Georgia State University. This database consisted of 1,024 students who began their baccalaureate education at GSU, graduated, and then continued in graduate or professional education at GSU. To qualify for inclusion in this database, a student must have completed 14 or more quarter credits at GSU. This same criteria also applies for Native State students. A student who completed more than one quarter (15 credits) at another institution prior to enrolling at GSU was not included in the Historical Group. The database was drawn from all student transcripts at GSU between 1975 and 1985. This population was selected because 1) it was a readily available database, 2) prior research demonstrated that it was amenable to statistical analysis (Prather & Smith, 1976a, 1976b; Prather, Smith & Wadly, 1976), and 3) the transcript records contained SAT and GRE information as well as courses taken.

From this database, 56 student records were found to contain the Scholastic Aptitude Test verbal scores (SAT-V), Scholastic Aptitude Test mathematical scores (SAT-M), Graduate Record Examination verbal score (GRE-V) and Graduate Record Examination quantitative score (GRE-Q). All student identification information was removed from this database at GSU, so the individual identity of the student was unknown to the researchers developing the cluster analytic model. It should be noted that these 56 student transcripts were representative of the GSU student population in every way other than by major. Approximately

20% of the sample were found to be psychology majors and another 20% were English majors. The spread of SAT scores appeared to otherwise approximate the demographic characteristics of GSU students. Therefore, the sample did provide a database in order to develop the model.

The historical database contained 1,024 transcripts upon which were listed an unduplicated count of 2,470 discrete course numbers and grades. The sample of 56 transcripts with complete GRE and SAT test score information contained an unduplicated count of 1,065 discrete course numbers and grades. No evidence existed that a particular course offered in a particular year was indeed identical to a course bearing the same course number in another year. The comparability of courses in a cross-sectional study of a single cohort of college seniors may be less than that of a historical group, since the potential differences between courses bearing the same course identification number would only vary over about 4 years (from courses taken by the cohort when they were freshman to those completed as seniors). A historical database accentuates the potential for significant changes in course structure, content or staffing. Nevertheless, for the purposes of model building and preliminary analysis, courses of the same course number taken in different semesters or years were assumed to be comparable.

Courses repeated for credit were eliminated from the analysis. For example, MUS 101 was found to be a performance music class. One section of this class might be performance oboe, while another might be performance piano. Thus, students interested in music enrolled in multiple sections of the class during one term and enrolled repeatedly in the course over several terms. Likewise, HON 326 was found to be an honors seminar in the arts and humanities one quarter, in the social sciences the next quarter, and in the physical and life sciences yet another quarter. Therefore, these courses were eliminated from the analysis because they violated the assumption of comparability of the course number over the quarters represented by the historical database.

Figure 1-1. Transcripts in the GSU Historical Database

	TOTAL DATABASE		SAMPLE	
	N	Percent	N	Percent
Transcripts	1,024	100%	56	5.47%
Unduplicated Course Numbers	2,470	100%	1,065	43.12%
Courses Taken By 5 or More Students			101	4.03%

Prior research (i.e., Blackburn et al., 1976; Drees, 1982) used a five percent sample of transcripts upon which to base generalizations regarding the undergraduate curriculum. The above analysis of the Historical Group database at GSU suggested that a 5 percent sample of transcripts would yield over 40% of the available courses in the college curriculum, but only about 5 percent of the curriculum will be represented by 5 or more students in the sample. Therefore, generalizations about specific courses across a broad spectrum of the curriculum cannot be made based on the course-taking behavior of 5 or more students. Only those courses most frequently chosen by students may be included in such an analysis. Obviously, average class size has a bearing on the number of courses available for analysis, given a specified transcript sample size and minimum number of students required in each course cell in the cluster data matrix. An area needing further research is that of the relationship between sample size of transcripts and representativeness of the curriculum as a whole.

<u>The relationship between sample size and the college curriculum</u>

A persistent problem in linking the undergraduate curriculum to measures of student learned abilities is the number of courses from which students may choose. As previously mentioned, students will typically enroll in 35 to 55 separate courses to complete their bachelor's degree, although the number of courses vary considerably. Students select these 35 to 55 courses from a catalog of several thousand courses at a university or several hundred at a smaller college. Linking the effect of one course to the general learning of students therefore becomes problematic.

Two samples of graduating seniors at Georgia State University (GSU) were drawn during 1986-87 and 1987-88. This report describes the results of the native students who began and completed their baccalaureate degree at GSU. However, since the individual sample sizes were small, a decision was made to combine the samples together resulting in a larger sample size to examine the important relationships. All of the data presented in this report concerns the combined sample.

There were 7,850 total courses appearing on the transcripts of the 168 students. After courses that were cross-listed or had equivalent numbers (through catalog changes) were identified; 1,244 unduplicated courses were counted on the 168 student course transcripts. Of the 1,244 courses, 300 were taken by 5 or more students in the Georgia State Native Group. The preliminary analysis, therefore, focuses on these 300 courses (most frequently chosen by students).

Figure 1-2a. Summary of Georgia State Native Group

	USABLE SAMPLE N	Percent
Transcripts, GRE Tests	168	
Duplicated Courses	7,850	
Unduplicated Courses	1,244	
Number of Courses Taken by 5 or More Students	300	24.12%
Number of Courses Taken by 2 or More Students	704	56.59%

The question of the representativeness of a sample of courses to the total curriculum is exacerbated further by the lack of a precise definition of the total curriculum. As was evidenced by the analysis of Georgia State Native student transcripts, the exact number of courses available to students does not correspond to the college catalog. Certain courses are offered in alternate years; others are offered less frequently. Some courses are cancelled for lack of enrollment; others are split into multiple sections taught by different faculty due to large student demand. The exact number of unduplicated courses listed in the Georgia State curriculum database was not available to the DCP Project researchers. Likewise, the exact number of courses available for enrollment in any given year was not available. The courses in one year were not exactly identical to those offered the following year. What constitutes the curriculum, in terms of number of courses, content and variety, varies from term to term and year to year.

Without an exact definition of the total curriculum available to undergraduates, the representativeness of a sample of courses can only be approximated. Since that definition of the curriculum evolves over the period encompassed by a baccalaureate program, and since students enter and exit the baccalaureate programs in different terms and the tenure of their undergraduate studies varies, the exact extent of courses from which a student can make choices becomes individual, nebulous and imprecise. Even so, the data from the Georgia State Native group reflects the extent of curricular change in even the most frequently enrolled courses over a six-year period generally covered by the transcripts. More research is needed in the variability of the course offerings on a yearly basis.

In the DCP Project research, samples of student transcripts were drawn and those courses enrolling 5 or more students were examined in the quantitative cluster analysis. When those courses enrolling 5 or more students were selected, the proportion of the total curriculum represented by those students was significantly decreased. When the initial sample size is not very large, the representativeness of the courses to the total curriculum may be seriously questioned. However, many debates regarding the vitality of the undergraduate curriculum in producing general learning among students consider only the general education portion of the curriculum, not every course listed in the catalog. From that standpoint, the representativeness of the courses included in the cluster analysis may be defined in terms of either (a) the total of courses offered during the period of enrollment of the student, or (b) the combinations and sequences of courses prescribed by the college or university to meet the general education requirements for a bachelor's degree.

The total courses offered during the period of enrollment of a student is not easily ascertained at many colleges and universities. First, the transcripts of a cohort of students list only what the students chose, not what was offered but they didn't chose. Student choice of coursework is not made in isolation, but is made in relation to those courses not selected, those previously selected, and those planned for future terms. Second, not all courses offered during a given period are listed in the college catalog or bulletin. Experimental courses and new courses, some of which may be extended only in one year, do not appear in the catalog. Comparing the student transcripts with the college catalog reveals this. Thus, courses not listed in the catalog and not selected by a given cohort of students were among the range of enrollment choices available to the students. Lastly, there are courses in the college catalog which may not be given during the enrollment period of a cohort of students. While such courses were not choices to the student cohort, they were regarded as part of the formal curriculum of the institution. Thus, defining the curriculum as all courses available and/or advertised to a particular cohort of students may not produce an exact representation of the college curriculum. It may, in fact, obscure some of the most experimental and innovative courses which, for one reason or another, did not get recorded in the college catalog.

On the other hand, if one defines the curriculum pertinent to general learning solely in terms of what general education courses are required for degree completion, the distinction between what the college intends and what the effects of the college curriculum are is blurred. The possibility looms large that a student enrolled in coursework that enhanced his or her general learned abilities but was not part of the formal general education requirements of the institution. Previously mentioned problems also exist with this definition of the curriculum as well: courses not selected are not fully represented, courses not listed in the catalog may be overlooked, and courses listed by not offered are treated as part of the range of options. In sum, the undergraduate curriculum is not a tidy item for analysis.

For the purposes of the cluster analysis, the quantitative meaning of course attributes are more important for generalization than the sample representativeness. The effect of a given pattern of coursework (its quantitative attributes, particularly) on a given student are more germane to determining the differential effect of coursework than is the representativeness of that course to the total curriculum. If one wanted a sample of courses representative of all listed in the entire curriculum, one would need a large enough student sample so that the courses appearing on the transcripts of 5 or more sample students would be representative of the total curriculum. This, again, presumes a means for determining the totality of a curriculum, given changes in courses offered over the period of student enrollment. It also requires an investigation of the relationship between the representativeness of courses to the curriculum and the relationship of the representativeness of the sample transcripts to the student cohort or population studied.

However, an alternate interpretation of the relationship between course attributes and their reliability would yield a different perspective on the above problem. In the initial analysis of the Georgia State Native group, the criterion variables used were correlation coefficients between SAT and GRE scores for those enrolling in a given course. Here, the probability of error varies according to the number of enrolled students. When GRE item-type score gains are used as course attributes, however, this does not seem to be the case. The residual score gains calculated among all students exhibited high confidence levels, as the regression functions of SAT scores on GRE item-type scores proved significant. The remaining concern, then, is the level of confidence attributable to a single course when it is described by the mean of student residual scores from the sample group who enrolled in the course.

At this juncture, it is important to note that the focus of the analysis is on courses, not students. It is not the purpose of the cluster analysis to predict the population mean parameter of all the students enrolled in a course. Since the main purpose of the cluster analysis of college curriculum is to examine the effect of an unknown course enrollment pattern on student general learned abilities, the confidentiality of mean residuals for a course is not of much importance because the attributes are in large part significantly determined by all students in the sample group, rather than by the students enrolled in the course. Thus, there is no reason for deleting those courses enrolling 4 or less students from the cluster model building because the course attributes are determined by student course enrollment pattern, not by the characteristic of a single course.

The analysis of the Georgia State Natives discussed later in this report revealed that each coursework cluster includes a certain variety of subjects and levels, ranging from those intended for freshmen (100 level courses) to those designed for seniors (400 level courses). These clusters, derived of courses sorted according to the gains in general learned abilities of the students who took them, generate questions regarding the basic attributes of the college curriculum: discipline, sequence and level.

Assumptions

1. One learns what one studies.
2. Courses are the primary units of learning in college.
3. Transcripts are an accurate listing of the enrollment pattern of students.
4. Most undergraduate courses are basically stable in content and instruction over time and among instructors.

5. The effects measured can be generalized to all the formal coursework in which a student enrolled.

Limitation in analysis of curricular patterns

The analysis of coursework patterns that lead to higher student gains in general learned abilities should provide a description of the effect of different aspects of the undergraduate curriculum. The analysis should also point to those curricular characteristics and organizations which promise to be most effective for promoting cognitive development. However, the analysis is delimited to those students who were attaining the bachelor's degree at Georgia State University and the other institutions participating in the DCP Project. No analysis is presented of the differential effect of coursework on those students who ended their studies prior to completion of their senior year.

Two forms of error need to be avoided in such an investigation. One is the reductionist error of attempting to account for the variance in complex groupings of coursework through individual psychological variables. In a recent review of the literature on the effects of race, gender and class on educational attainment, Grant and Sleeter (1986) concluded that attention to one status group oversimplified the analysis of student behavior, confirming the problems of reductionist error. The reductionist error may also occur in research equating general learned abilities within complex academic organizations with intra-group cohesion and/or with individuals' identification with an academic discipline. The study of student learning in colleges and universities is a study of student behavior in such organizations, rather than the study of such organizations.

A second type of error is the uniqueness-of-data approach. While it is important to acknowledge what is unique in each institutional learning environment, this should not halt the exploration of appropriate relationships of curricula within different colleges and universities. This error may emanate from the failure to conceive of these institutions as systems (1) nested within and linked to larger systems (disciplinary and professional fields), and (2) containing smaller subsystems (departments, divisions and programs) that are, in turn, linked to them (Katz, Kahn and Stacey, 1982).

Prior research suggests that student coursework patterns found to affect general learned abilities can be characterized by (1) the extraneous (other than achievement) characteristics of the students enrolled, (2) the unique or idiographic characteristics of the learning environment, and (3) the normative effect of the fields of study on learning in colleges and universities (Astin, 1970a; Pascarella, 1985). Prior research has also demonstrated that more than one model of college curriculum can explain the effect on student learning from a common set of transcript data (e.g., Hesseldenz and Smith, 1977; Kolb, 1973). Therefore the cluster analytic model identifies empirically-derived course patterns which subsequently may be examined in terms of student characteristics and idiographic and nomothetic aspects of the curriculum. In this sense, the cluster-analytic model is retro-deductive in approach and is useful to the generation of research questions and hypotheses regarding common notions of the college curriculum and its relationship to general student learning at the undergraduate level.

Definition of terms and concepts

Transfer student: A student who has earned the equivalent of one or more terms of full-time work (15 quarter credits or 10 semester credits) at another institution of higher education prior to enrolling at the institution under study.

Native student: A native student has obtained his/her undergraduate educational experience primarily from the institution under study. Native students entered the college or university with no more than 14 quarter credits or 9 semester credits earned at other institutions. Native students may have accumulated coursework at other institutions during their bachelor's program (i.e., a student who attends summer session at another institution during her junior year), but such credit does not constitute a significant portion of their baccalaureate program.

Graduating senior: A student who has declared his/her intention to graduate or is estimated to graduate during the calendar year commencing July 1st andending June 30th.

Scholastic Aptitude Test (SAT) Scores: Students may have taken the SAT examinations more than once prior to admission. When more than one set of SAT scores was available for a given student, the SAT score date immediately preceding the initiation of the baccalaureate program was used. That is, if a student took the exam several times and entered college in September 1980, then the SAT scores from the test most immediately preceding September 1980 were used. The SAT is a precollege effects measure, and the more proximous the measure is to the initiation of the effects to be analyzed, the most desirable.

Quarter calendar: The calendar usually consists of four ten-week terms.

Semester calendar: The calendar usually consists of two terms which average fifteen weeks each. However, each term can be as long as twenty weeks.

Description of the GRE General Test

The GRE General Test purports to measure verbal, quantitative and analytic abilities important to academic achievement (Educational Testing Service, 1988). In doing so, the test reflects the opportunities and efforts of the student to acquire these abilities.

Verbal abilities (GRE-V). One of the major subscores of the GRE General Test is that of verbal ability. Verbal ability is described as the ability to reason with words in solving problems.

> Reasoning effectively in a verbal medium depends upon the ability to discern, comprehend and analyze relationships among words or groups of words and within larger units of discourse such as sentences and written passages. Such factors as knowledge of words and practice in reading will...define the limits within which one can reason using these tools (ETS, 1988, p. 28).

The GRE Verbal Subscore is derived from 4 types of items: analogies, antonyms, sentence completion and reading comprehension questions. Each is described below:

Analogies (ANA). Analogy items test students' ability "to recognize relationships among words and the concepts they represent and to recognize when these relationships are parallel. The process of eliminating four wrong answer choices requires one to formulate and then analyze the relationships linking six pairs of words" (ETS, 1988, p. 28).

Antonyms (ANT). Antonym items provide a direct test of the student's vocabulary. However, the purpose of this item-type is not merely to measure the student's vocabulary, but also to gage "the student's ability to reason from a given concept to its opposite" (ETS, 1988, p. 29).

Reading Comprehension (RD). To successfully complete these items, students must read narrative with "understanding, insight and discrimination". These passages challenge a student's ability to analyze using a variety of perspectives "including the ability to recognize both explicitly stated elements in the passage and assumptions underlying statements or arguments in the passage as well as the implications of those statements or arguments" (ETS, 1988, p. 31). Due to the length of the narratives around which the questions for this item-type are built, students are given ample opportunity to assess a variety of relationships, such as the function of a key word in a passage, the relationships among several ideas, or the relationship of the author to the topic or the audience.

Sentence Completion (SC). These items determine the student's ability to "recognize words or phrases that both logically and stylistically complete the meaning of a sentence" (ETS, 1988, p. 30). The student must decide which of five words, sets of words or phrases can best complete a sentence. In completing this type of task, the student must consider which answer gives the sentence a logically satisfying meaning and stylistically integrated whole to the discourse.

Quantitative Ability (GRE-Q). The second subscore of the GRE General Test measures basic mathematical abilities, the understanding of basic mathematical concepts, the ability to reason quantitatively and to solve problems that require skills in mathematical analysis. The quantitative items seek not to exceed the abilities common to undergraduates, regardless of field of study. Questions test the student's facility with arithmetic, algebra and geometry. Questions may be in words, metric units and symbols or figures, graphs and tables.

Regular Mathematics (RM). This quantitative item-type has also been labelled Discrete Quantitative questions and Arithmetic, Algebra and Geometry in various GRE and ETS publications.

Quantitative Comparisons (QC). These items test the student's ability "to reason quickly and accurately about the relative sizes of two quantities or to perceive that not enough information is provided to make such a decision" (ETS, 1988, p. 34).

Data Interpretation (DI). Data interpretation items presents sets of data in graphs and tables and ask students to synthesize the information, choose the correct data to answer the question, or to determine that the information needed is not present in the data set.

Analytic Ability (GRE-A). The third subscore of the GRE General Test is designed to measure students' ability to think analytically. This subscore is comprised of two item-types: Analytic Reasoning and Logical Reasoning.

Analytic Reasoning (ARE). Analytic reasoning items measure a student's ability "to understand a given structure of arbitrary relationships among fictitious persons, places, things, or events, and to deduce new information from the relationships" (ETS, 1988, p. 38).

Logical Reasoning (LR). These items assess a student's ability to understand, analyze and evaluate positions and contentions. Specific questions may evaluate a student's ability to recognize a point of argument or the assumptions on which a position is based, to draw conclusions or form hypotheses, to assess the manner of arguments and the evidence supporting them.

While the GRE General Tests are designed to describe the student's broad verbal, mathematics and analytic abilities, the 9 individual item-types of the Test provide discrete measures of general learned abilities. One should avoid, however, making the assumption that the GRE measures <u>all</u> general learned abilities associated with collegiate learning or even those intended as the educational goals of a particular college, university, program, major or course. Nevertheless, the GRE provides a broad set of measures of general learning from which a model to assess selected gains in cognitive development of college students.

Summary

In this section the purpose, scope, and method of the DCP Project were described. The purpose of the research was to test the hypothesis that student enrollment in different patterns of coursework affects the development of their general learned abilities.

There was no clear consensus in the literature reviewed as to what constitutes the general learned abilities of college students. There was general agreement that the assessment of students' general cognitive development necessitates multiple measures of general learning.

One set of such measures consists of the 9 item-types of the general test of the Graduate Record Examination. The GRE General Test has been criticized as an assessment measure of baccalaureate learning because of the limited number and advanced abilities of the students upon which the tests were normed. Similarly, the multiple choice format of the GRE has been criticized for not measuring higher-order reasoning and creative thinking skills. These criticisms notwithstanding, the GRE presents a common set of measures of general collegiate learning.

The strong correlation of the GRE with the Scholastic Apptitude Test (SAT) affords an opportunity to control the assessment of student learning for the comparable knowledge, skills and abilities students possessed upon admission to college. The largest amount of variance in general learned abilities logically should be attributable to learning prior to college. Nevertheless, when such learning is removed from the analyses, residual scores should provide indicators of students' development during the college years.

Just as determining what constitutes student achievement in college is problematic, so too is the determination of what the formal curriculum of a college or university is. A distinction in the DCP Project is made between the intended curriculum, as stated in the college catalogs and bulletins and the actual curricular record, as represented on the student transcript. A coursework pattern was defined as a set of courses whose effects on general learning are similar. This definition is an empirical artifact of student enrollment behavior, rather than an academic plan or stated curricular sequence, as might be found in a catalog or program brochure.

By clustering courses into patterns according to their effect on general learned abilities, a basis is provided for examining what students took in light of what they learned. If what the GRE measures was what the college intended as the outcomes of the general education curriculum, and if the course shown to affect positively the general learning of undergraduates were the same as the colleges general education requirements, then that college may take pride in the evidence of the effectiveness of its curriculum. But such a comparison of what a student takes with what that individual learns is predicated upon the hypothesis that enrollment in a different pattern of coursework leads to different effects in general learning.

To test the differential coursework hypothesis, a cluster analytic model was developed. The residual scores of GRE item-types were attributed to the specific coursework in which students enrolled. Each course was described in terms of the mean of residuals of the students who had enrolled in the course. Thus, there were 9 mean item-type residuals for each course found on student transcripts. Next, courses were sorted and clustered according to these 9 criterion variables. Finally, the validity of the groupings was tested using discriminant analyses. From the discriminant analyses, coursework affecting general learning could be differentiated from that serving some other role (such as learning within the major or learning not measured by the GRE).

Through the development of the cluster analytic model, the effect of coursework on general learned abilities may be assessed. Furthermore, the extent to which the item-types of the GRE represent discrete measures of general learning can be assessed. Similarly, the intentions of a college or university general education curriculum can be compared to empirically-derived coursework clusters found to be associated with gains in general learning. Thus, the model can be used to assess student learning to determine the strength and independence of the measures of learning selected, and to compare the intended curriculum with the actual course-taking behavior of students.

II. Methodology and Procedures: Cluster Analytic Model

A conceptual/empirical approach was used in the selection, testing and adoption of a specific methodology for the analysis of coursework patterns. The approach was conceptual in that theoretical concepts differentiating coursework discussed in the previous section restricted the empirical approach to conform to the nature and orientation of the research problem. What follows is a discussion of the process of cluster analysis and its application to the investigation of coursework patterns; in that discussion, cluster analysis is contrasted to other statistical methods of potential value to the research investigation.

Previous transcript analysis studies have used the general linear model and regression analysis (Benbow and Stanley, 1980, 1982; Pallas and Alexander, 1983; Prather and Smith, 1976a, 1976b). The rationale for the use of regression is based upon practical and theoretical justifications. Regression analysis allows maximum design flexibility and is statistically robust. Transcript analyses involve large amounts of data. For example, Prather et al. (1976) examined 8,735 student transcripts which collectively contained 189,013 individual course grades. Regression analysis provides an effective technique for presenting the diverse nature of the data while maintaining a consistent analysis rationale. However, the general linear model does not provide a direct means of assessing the additive and temporal aspects of course patterns, as described in the previous chapter.

To distinguish cluster analysis from other approaches, certain terms need definition. The term classification is used here to refer to the categorization of the courses in which students enrolled over the duration of their baccalaureate program. It is the systematic and unique way a college or university labels and arranges its courses (i.e., Honors 101, French 340, etc.); that scheme or arrangement of classes is already known in a disaggregate form on student transcripts. Identification is the allocation of individual courses to be established in categories on the basis of specific criteria (i.e., Biology 205 is classified by many universities as a sophomore level class in the department of Biology).

Discriminant analysis is a process undertaken to differentiate between groups formed on an a priori basis (See Biglan, 1973a for an example). It is the objective of discriminant analysis not to discover groups, but rather to identify a set of characteristics that can significantly differentiate between the groups. The process allows the analyst to allocate new cases to one of the a priori groups with the least amount of error. In contrast, cluster analysis recovers groups representing particular patterns from diverse populations (Lorr, 1983; Romesburg, 1984). In the model developed to analyze coursework patterns, cluster analysis is used to classify courses according to student achievement criteria, while discriminant analysis is used to test and provide secondary validation of the cluster groupings and to identify those criteria which significantly differentiate one cluster of coursework from another.

Factor analysis is different from cluster analysis in that its attention is on the similarity of the variables (attributes). The aim is to identify a small number of dimensions (factors) that can account for individual differences on the various measures or attributes. Thus, the aim of factor analysis is to reduce or consolidate the number of attributes of a variable set while the purpose of a cluster analysis is simply to classify or taxonomize data into groups on the basis of a set of attributes. Miller (1969) examined 48 common nouns; through cluster analysis he identified five subgroups referring to living things, nonliving things, quantitative terms, social interactions, and emotion. Another example of cluster analysis is Paykel's (1971) analysis of 165 depressed patients. Using symptom ratings and historical variables, he grouped the patients into four clusters: the retard psychotic, the anxious, the hostile, and the young depressive. Cluster analysis refers to a wide variety of techniques used to classify entities into homogenous subgroups on the basis of their similarities.

The end products of cluster analysis are clusters or pattern sets. Since the exact number and nature of the course patterns is not known in advance, the clustering process is actually technically preclassificatory. In other words, cluster analysis techniques are used to construct a classification scheme for unclassified data sets. In this way, cluster analysis empirically arranges the courses of a college curriculum using student decision-making behavior (as represented on transcripts) as the primary source of information. The courses are classified in a hierarchical dendrogram or tree. The relationship between courses is determined by their similarity on the criteria used in the classification. In this way, the similarity between courses is determined empirically, rather than by arbitrary concepts (i.e., "life sciences") or levels (i.e., "freshmen level survey"). This conceptual/empirical approach was selected due to the lack of agreement in the higher education literature on a common research paradigm, model or philosophy for the organization of coursework (Bergquist et al., 1981; Biglan, 1973a; Furhmann and Grasha, 1983; Gaff, 1983; Rudolph, 1977; Sloan, 1971; Veysey, 1973).

Cluster analysis conforms to the conceptual restrictions placed on the model in order to assess the effect of coursework patterns on student learning. Cluster analysis provides a statistical procedure for examining coursework using multiple criteria. It can accommodate both quantitative and qualitative attributes of varying dimensions. Thus, the criterion selected need not be test scores; nominal, order, interval and ratio data have been successfully used as attributes in cluster analysis (Romesburg, 1984). Cluster analysis uses these attributes to arrive at patterns of coursework independent of any institutionally prescribed a priori distinctions among courses. It therefore is capable of testing notions of combinations, sequence and progression of courses within the college curriculum. It leads to the discovery of clusters (or patterns) of coursework in student transcripts, based on the attributes of students' general learned abilities. Since the purpose of the cluster analytic model is to group coursework homogeneously according to its relation to student learning outcomes (Lorr, 1983; Romesburg, 1984), cluster analysis was chosen as the primary methodology for analyzing student transcripts in this Differential Coursework Patterns Project.

General procedural steps

This section describes the steps in the statistical process embodied in the cluster analytic model. These steps address the five research objectives (discussed in Section 1) of the model. Student residual scores are derived. Student transcripts are examined, and courses reported on them are clustered into patterns based on the score gains of the students who enrolled in the courses. Resulting patterns of coursework are again analyzed and classified according to the sequences and combinations of courses within the cluster and according to term of enrollment data found on students transcripts. Also, resulting patterns of coursework are analyzed and classified according to attributes associated with the educational environment of the college or university: (a) the type of college or university, as indicated by Carnegie classification (1987), (b) the type of general education degree requirements of the institution, as indicated in the college catalog or bulletin, (c) the type of academic discipline or field of study, as indicated by the course prefix on the transcript, and d) the student demographic characteristics, as indicated on the demographic questionnaire completed by the student at the time of GRE testing. Hypothesized patterns of coursework generated from one set of student transcripts may be validated through the replication of the cluster analytic model using a second sample of student transcripts.

Quantitative versus qualitative measures

As previously described in Section 1, there is more than one view of what constitutes representation of a college or university curriculum within a sample of student transcripts. One view suggests that only those courses in which students most frequently enroll constitutes the curriculum associated with general learning in the undergraduate program. A second view holds that any course offered may contribute to the general learning of students. The first view implies a more restricted view of the curriculum than does the second. These contrasting views resulted in the development of two alternate procedures for assessing the associated effects of coursework patterns on general learned abilities. Reported in the following section are the results of the first procedure, the quantitative cluster analysis. The second procedure, qualitative cluster analysis, is described thereafter.

The cluster analytic model uses multiple measures of general learned abilities as attributes with which to classify courses taken into patterns. These attributes can be expressed quantitatively or qualitatively. For example, a sophomore level mathematics class (i.e., Math 201) can be described according to the mean residual score of students (from the sample) who enrolled in the course. Math 201 can also be described nominally; here the researcher simply notes whether one or more students with high residual scores enrolled in the course. Both the quantitative and qualitative descriptions of Math 201 serve to determine the relation of the course to other courses according to the item-type criteria variables.

When a sample of students is used to examine the effects of a particular college curriculum on general learning, there are a limited number of courses within the curriculum which can be analyzed quantitatively. The GSU Historical Group example, previously described, illustrated this problem. Only a limited percent of all courses appearing on the sample transcripts can be analyzed if the number of students enrolling in a given course is a concern in the analysis. However, such quantitative analysis of the curriculum can yield much more accurate information regarding the effect a particular course may have on a given measure of student general learned ability. To generalize about a course on the basis of 5 or more student residual scores provides a level of information that far exceeds that of simply noting whether any student who performed well on a given measure enrolled in that course.

There are advantages and disadvantages to either the quantitative or the qualitative approach. In the quantitative analysis, a limited number of courses can be examined, but, in practice, those courses are those in which most students enroll and encompass all those in which students are required to enroll. Math 101, a required mathematics course in a college's curriculum, would be included in those courses examined in a quantitative cluster analysis since all students are required to enroll, while Math 450 designed primarily for senior level math majors would not be included -- assuming the sample of students is random and not confined to mathematics students.

There are those, however, who may argue that it is the advanced coursework within a given discipline which facilitates general student learning. It has been suggested that the study of liberal arts disciplines teaches students a mode of inquiry which facilitates their learning of other forms of knowledge, abilities and skills (Biglan, 1973a, 1973b). Similarly, courses with traditionally restricted enrollments may not appear in an analysis of coursework selected by the frequency of enrollment. Analysis of the effect of credit for study abroad or honors programs or the assessment of coursework patterns of specific groups of students might not be possible. Therefore, under these and related circumstances, it is desirable also to examine as many courses of a student's transcript as possible, rather than restricting the analysis to only those courses in which students most frequently enroll.

Examination of <u>all</u> courses on a student's transcript may not be feasible. Some courses may have only one student enrolled from the sample group, the cohort, or population of students examined. Recall that in the cluster analytic model, a student's GRE item-type residuals are attributed to <u>all</u> the courses in which he/she enrolled. The contribution of individual courses to the curriculum is calculated as the sum of the effects of the students who enrolled in those courses. Courses with low enrollments from the group being examined have higher margins of error because the effects are discerned from a smaller number of students. Thus, courses with an enrollment of one student from the sample group do not provide a basis for quantitative analysis, while courses with limited enrollment (2 or more) may be amenable to the treatment of that enrollment solely as a nominal variable.

In a quantitative cluster analysis, the metrics used for each course are the mean GRE item-type residuals which contain interval information about the gains of students who enrolled in the course. In a qualitative cluster analysis, the metrics used are whether students with high residual scores did or did not enroll; the metric is reduced to a dichotomous nominal variable. There is a trade-off in a qualitative cluster analysis between inclusiveness of the curriculum and precision of the information.

Any quantitative attribute, such as a GRE item-type residual, can be dichotomized and converted into a binary attribute (Anderberg, 1973). Such a procedure lessens the precision of information in the data set because the process is irreversible. The data from an interval scale is collapsed into a nominal one. It is commonly held that ratio scales provide more precise information than interval scales, that interval scales are more precise than ordinal ones, and that all the preceding are more informative than nominal scales. However, the choice of scales is constrained by different factors.

First, institutional researchers are often under monetary constraints. The costs of obtaining test scores for all college graduates, for example, may not be feasible on an on-going basis. Hence, it may not be practical to gather the number of student transcripts and assessment information needed to use the quantitative cluster analysis with courses other than those in which students most frequently enroll.

Second, institutional researchers have a choice between an intensively detailed picture of the curriculum using the ratio data of mean residuals or a less detailed picture provided by binary information. As has been previously discussed, there are occasions when the scope of the analysis is to be preferred over the precision of the analysis.

Third, "data do not automatically inform the researcher" (Romesburg, 1984). To have meaning, transcript and test data must be interpretable within a curricular context. The primary question is, "Which coursework patterns contribute to general student learning?" The secondary questions are, "How much do the patterns contribute?" and "What is their relative contribution?" Qualitative analyses are not categorically inferior. In this case, a qualitative analytic question precedes the one which may be answered quantitatively.

Procedure 1: Quantitative cluster analysis

Described below are steps required in Procedure 1 (Quantitative Analysis) to assess the effects associated with the coursework patterns on the general learned abilities of college students. The research design uses as data sources transcripts and GRE and SAT test scores from a sample of students. The 9 item-type categories of the General Tests of the Graduate Record Examination are used as measures of general learned abilities of college seniors. These seniors' SAT scores are used as variables to control for the academic abilities of these students when they first entered college. The student transcripts are used as the record of the sequence of courses in which these seniors enrolled.

The first objective of the cluster analytic model is to determine the student improvement in general learned abilities over the time of their baccalaureate program. To do this, first the residual score of each item-type for each student is calculated; the residual score is the difference between the student's actual score and the score predicted by the student's corresponding SAT score. Thus, for each student outcome measure there is a student residual score for each person in the sample group.

The second objective is to determine patterns of coursework on the student transcripts which are associated with student residual scores. This is accomplished through cluster analysis, using student residual scores (GRE item-type residuals) as attributes of the courses in which students enrolled.

A raw data matrix consisting of columns of courses and rows of residual scores is created. The mean residual score for all the students in the sample who enrolled in a given course is calculated and becomes the metric value for that course. The correlation coefficient is used as the <u>**resemblance coefficient**</u> to transform the data matrix into a resemblance matrix, wherein the similarity of residual scores for students enrolling in one course can be compared with those enrolled in another course. Once the <u>**resemblance matrix**</u> indicating the proportional relationship of courses is established, a clustering method is selected and executed to arrange a tree or dendrogram of courses related by the mean residual of each course. Next, a discriminant analysis is performed on the resulting clusters of coursework to (a) determine the extent to which the courses have been correctly classified according to the 9 mean student residual scores, (b) to determine which of the 9 mean residual scores were correlated with particular discriminant functions, and (c) to determine which coursework clusters exhibited high mean residual scores relative to each discriminant function. From the discriminant analysis an association can be inferred between coursework patterns (clusters) and general learned abilities (mean residual scores on 9 criterion variables). The cluster-analytic procedure groups courses frequently chosen by students according to the strength of their associated effect on the student residual scores.

Described in greater detail below the steps followed in this cluster analytic procedure:

<u>Step 1</u>. Calculate a student residual score for each item-type (attribute) of each student GRE. This step removes the predictive effect of the student's SAT scores from the GRE item-type, thereby controlling for the academic ability of the student upon entrance to college. For GRE Quantitative item-types, the effect of the student's SAT Math score is partialled out. For the GRE Verbal item-types, the effects of the SAT Verbal score is partialled out. For the GRE Analytic item-types, the

effect of the combined SAT Verbal and SAT Math scores are partialled out. In this way, the student's academic abilities prior to entering college is controlled when calculating student residual scores.

Step 2. Calculate the mean residual score for each course enrolling 5 or more students from the sample group. Cross-listed courses are standardized so that they have only one identifier. Cross-listed courses include those with identical numbers that have different labels. Courses with the same course identifier but with abstentiously different content (i.e., "Music 101: Voice" and "Music 101: Piano") are excluded from the analysis; however catalog changes are accounted for. If Math 201 in 1982 was renumbered as Math 211 in 1985, Math 201 and Math 211 for those years are treated as the same course for the purposes of analysis.

The proportion of courses included in the analysis is related to a) the extensiveness of the course listings in the curriculum, and b) the size of the student sample. The more extensive the curriculum, the less frequently 5 or more students from the sample will have enrolled in the same course. Likewise, the smaller the size of the student sample, the less frequently 5 or more students from the sample will have enrolled in the same course.

Step 3. Create a raw data matrix by using the mean residual scores of the sample and the courses found on 5 or more of the student transcripts. The rows in the data matrix consist of the 9 GRE item-type scores while the columns represent those courses enrolling 5 or more students. Each cell value of the matrix is a mean GRE item-type residual score for those group students enrolling in a specific course. For example, the course (object) in the first column in the data matrix is ANTHROPOLOGY 101, and the student outcome measure in the first row of the data matrix is DATA INTERPRETATION. The student residual scores are .40, .45, .50, .55, and .60; the mean residual score, therefore, is .50 and is entered as the metric variable in cell (1,1) of the matrix. Since the variables in each row are of the same magnitude, and therefore, have comparable effect on the resulting cluster analysis, the data matrix does not need to be standardized (Romesburg, 1984). The cluster analysis will taxonomize courses in the curriculum according to whether students who showed positive gains on each item-type were enrolled in the courses. This step prepares a raw data matrix to be used in a general cluster analysis based on quantitative data.

Step 4. Select a resemblance coefficient. The resemblance coefficient (Romesburg, 1984) is also called the similarity index (Lorr, 1983). The purpose of the resemblance coefficient is to explain the similarity (or dissimilarity) of each cell to each of the other cells in the data matrix; it is expressed mathematically. There are many resemblance coefficients; each will express the similarity between courses (objects) in a slightly differently way. Each coefficient is appropriate for achieving slightly different research goals.

The resemblance coefficient selected for this study is Pearson's product-moment correlation coefficient. It is appropriate for use with ratio data. The resemblance coefficient will indicate the similarity of courses to each other according to the 9 item-type residuals (attributes) coded in the data matrix. The resemblance coefficient expresses the relationship of two courses proportionally.

Step 5. Calculate a resemblance matrix from the raw data matrix. The resemblance matrix is calculated by transforming the raw data matrix using the correlation resemblance coefficient. In this cluster analytic model, the data matrix consists of quantitative data described by 9 attributes ranging in value from 1.00 to -1.00. In the resemblance matrix, the columns represent the first course (object) in a pair, the rows represent the second course (object) in a pair. The resemblance coefficient (Pearson's *r*) is entered into each cell. The cell value represents the extent to which the attributes on the first course explain the variance in attributes on the second course. The resemblance coefficient serves as a measure of similarity between one course and each other course in the calculation of clusters or coursework patterns.

Step 6. Select and execute the clustering method. A resemblance matrix is transformed into a tree of related courses (objects) by use of a clustering method which is a series of steps that removes values from the resemblance matrix. Therefore the size of the matrix is reduced. Each time a value is removed from the resemblance matrix it is placed in the cluster tree or dendrogram. In the last step, the resemblance matrix disappears completely and the tree is completed as the last value is inserted.

Romesburg (1984, p. 139) recommends the unweighted pair-group method using arithmetic averages (UPGMA), also known as the average linkage method. UPGMA is recommended over single linkage clustering method (SLINK) and complete linkage clustering method (CLINK) for two reasons. First, it can be used with any resemblance coefficient, while SLINK and CLINK are designed to be used with interval and ratio data in a quantitative data matrix. Second, it judges the similarity between pairs of clusters in a less extreme manner than do SLINK and CLINK. The average linkage method (UPGMA) is available on SPSSx, SAS and BMDP statistical packages.

Step 7. Determine the optimum number of coursework clusters. Cluster analysis is a procedure for taxonomizing or classifying coursework data. The number of groups or patterns in which the data is classified according to the criterion variables is an arbitrary one. Once relationships between courses have been determined, the researcher must decide on how many groups in which to put the data. Discriminant analysis provides a means to test the secondary validity of the coursework pattern groupings.

By computing successive cluster analyses for different numbers of clusters and then conducting discriminant analyses on the resultant groupings, one can identify the number of clusters which has the highest predictive value, given the criterion variables used. Using the DISCRIMINANT program in SPSSx, for example, will identify how many members of each coursework pattern or cluster were correctly classified, how many could be classified in other patterns, and what was the overall percentage of correct classification.

The number of clusters with the highest predictive value may not be the sole objective in examining the merits of different cluster solutions to the cluster analysis. Theoretically, a four cluster solution may have high predictive value for GRE item-types because the item-type residuals are forced into three discriminant functions which should approximate the GRE sub-scores. Likewise, a 10 cluster solution may prove to be slightly less predictive, but the 9 GRE item-type residuals may be more clearly associated with discrete coursework patterns. Careful visual inspection of the cluster dendrogram often suggests appropriate cluster solutions to test using discriminant analysis.

Step 8. Determine which criterion variables contribute significantly to which discriminant functions. DISCRIMINANT in SPSSx, for example, calculates the pooled within-groups correlations between the discriminating variables (in this case, the mean residual scores on the 9 item-types) and the canonical discriminate functions. Large positive and negative correlations are identified. Eigenvalues for each discriminant function are assessed. Eigenvalues express the proportion of variance in student scores explained by the discriminant function. Discriminant functions that explain less than 5 percent of residual score variance or that have a probability of error exceeding .001 are discarded. Next, the group means for each coursework cluster can be examined. In this manner, the patterns of coursework associated with one or more mean item-type residual scores can be identified.

Step 9. Repeat Steps 1 to 8 using a second cohort of students. Following Steps 1 through 8 will produce a set of hypothesized relationships between coursework patterns and student residual scores on 9 criterion measures of general learned abilities. Hypothesized relationships cannot be tested or validated using the same data. Therefore, a second institutional sample is drawn. A second group of students are tested and a second set of transcripts and student residual scores are evaluated. Repeated use of the model should refine and clarify members within each coursework pattern.

Through the above 9 steps, the cluster analytic model classifies the most frequently enrolled courses according to their associated effect on student residual scores. Procedure 1 classifies courses according to a ratio index of similarity to other courses. While Procedure 1 may examine only a fraction of all the courses in a college curriculum, it does provide a means to differentiate the effect of required courses or courses in which most students enroll. For example, in the GSU historical database used in model-building and testing, a five percent sample of student transcripts enabled an examination of only five percent of courses appearing on those transcripts (the percentage of courses enrolling 5 or more students from the sample group). However, the courses examined in that 5 percent corresponded closely to those courses identified as meeting the College's distributional degree requirements in general education. Similarly, 146 Ithaca transcripts (Sample #1) yielded 405 individual courses enrolling 5 or more of the students from a list of 1,136 unduplicated courses. While these 405 courses represented over one-third of all courses on the transcripts, a majority of the courses were those listed in the

Ithaca catalog as meeting the general education requirements of the College.

III. Description of the Georgia State Native Combined Samples

This section describes the Georgia State combined sample (1986-87,1987-88) group of native graduating seniors.

Eligibility Requirements

Two criteria were established to determine eligible students from Georgia State (Natives) to participate in this study. Students had to meet both eligibility requirements in order to participate in the study:

1. a graduation date of May 1987 or an expected graduation date of December 1986 or May 1987 (these criteria are for inclusion in sample #1, the same criteria, except one year later, are used for sample #2); and

2. at least 84 total accumulated credits.

Any students with fewer than 84 total accumulated credits were excluded since, despite their "expected graduation dates" listed in the College's database, they would not be able to graduate by May 1987 (or May 1988 for second sample) taking normal course loads.

Combined Samples #1 and #2

The Georgia State Native Group consisted of the transcripts and test scores for 168 students from the combined sample #1 and sample #2. While the Georgia State Native Group did approximate the characteristics of graduating seniors for that year, several minor variations between the combined samples' student characteristics and those of the population as a whole are reported below.

Gender has been shown to be a significant factor in the academic performance of college undergraduates. Over one-half (56.5%) of the sample were female, while 43.5 percent of the population were female (see Figure 3-1).

Race and ethnicity also have been shown to be strong predictors of academic performance. Sixty-nine percent of the combined Group were white, compared to seventy-four percent of the graduating population. Blacks were overrepresented in the Group by seven percent while Asian students were underrepresented by six percent (see Figure 3-2).

Major field of study has been shown to be correlated to performance in the GRE examinations. The distribution of majors in the combined Group approximated that of the population. Majors in Information Systems and Journalism were slightly overrepresented while Finance, Studio, Accounting, and Marketing were slightly underrepresented (see Figure 3-3).

Figures 3-4a and 3-4b present the SAT scores for the combined Group and the population. The combined Group scored better on the Math portion (482.3) of the exam than the Verbal portion (471.3), as did the population, but the sample scored higher on the verbal.

Figure 3-1. Distribution of Georgia State Native Combined Sample: Gender

Gender	Combined Sample		Population	
	N	PERCENT	N	PERCENT
Female	95	56.5%	1173	55.6%
Male	73	43.5%	937	44.4%
TOTALS	168	100.0%	2110	100.0%

Figure 3-2. Distribution of Georgia State Native Group: Ethnicity

Ethnicity	Native Group		Population	
	N	PERCENT	N	PERCENT
Not specified	8	4.76%	0	.00%
Black	38	22.62%	336	15.92%
Native American	0	.00%	0	.00%
Asian/Asian American	3	1.79%	160	7.58%
Hispanic	3	1.79%	47	2.23%
White	116	69.05%	1,563	74.08%
Foreign	0	.00%	0	.00%
Other	0	.00%	4	.19%
TOTALS	168	100.00%	2110	100.00%

Figure 3-3. Distribution of Native Group: First Major

Major	Native Group N	Native Group PERCENT	Population N	Population Percent
Accounting	10	6.0%	189	8.9%
Anthropology	1	.6%	13	.6%
Art	1	.6%	17	.8%
Art Education	0	.0%	5	.2%
Actuarial Science	1	.6%	22	1.0%
Biology	5	3.0%	57	2.7%
Business Information	1	.6%	3	.1%
Chemistry	0	.0%	10	.5%
Community Health	1	.6%	12	.6%
Comprehensive Business Education	1	.6%	5	.2%
Computer Information Systems	0	.0%	20	.9%
Computer Science	2	1.2%	57	2.7%
Commericial Music	2	1.2%	34	1.6%
Criminal Justice	8	4.8%	59	2.8%
Decision Science	1	.6%	5	.2%
Economics	2	1.2%	22	1.0%
Early Childhood Education	2	1.2%	54	2.6%
Educ. Mental Retardation	1	.6%	5	.2%
English	4	2.4%	72	3.4%
Exercise Science	1	.6%	15	.7%
Finance	2	1.2%	107	5.1%
Film & Video	0	.0%	5	.2%
French	2	1.2%	18	.9%
German	0	.0%	5	.2%
Geology	1	.6%	4	.2%
Geography	2	1.2%	9	.4%
General Studies	2	1.2%	25	1.2%
Health Education	0	.0%	2	.1%
History	1	.6%	24	1.1%
Health Occupations Education	0	.0%	2	.1%
Hotel, Restaurant, Travel	4	2.4%	86	4.1%
Human Resources	2	1.2%	2	.1%
Insurance	0	.0%	9	.4%
Information Systems	9	5.4%	52	2.5%
Journalism	9	5.4%	68	3.2%
Middle Child Education	2	1.2%	14	.7%
Management	16	9.5%	189	9.0%
Mental Health	3	1.8%	19	.9%
Marketing	8	4.8%	157	7.4%
Marketing Education	0	.0%	0	.0%
Medical Technology	0	.0%	22	1.0%
Mathematics	3	1.8%	61	2.9%
Music	5	3.0%	34	1.6%
Nursing	3	1.8%	54	2.6%
Office Administration	1	.6%	17	.8%
Orchestra	0	.0%	3	.1%
Physical Education	0	.0%	6	.3%
Philosophy	2	1.2%	30	1.4%
Physics	2	1.2%	6	.3%

Political Science	4	2.4%	28	1.3%
Psychology	5	3.0%	93	4.4%
Physical Theraphy	1	.6%	15	.7%
Real Estate	0	.0%	13	.6%
Real Estate & Urban Affairs	0	.0%	10	.5%
Risk Management	0	.0%	21	1.0%
Respiratory Theraphy	0	.0%	16	.8%
Secondary Education	0	.0%	38	1.8%
Sociology	1	.6%	20	.9%
Spanish	2	1.2%	19	.9%
Speech	1	.6%	9	.4%
Studio	3	1.8%	94	4.5%
Theatre	1	.6%	8	.4%
Urban Studies	0	.0%	17	.8%
Trade and Industry	0	.0%	0	.0%
Unspecified	27	16.1%	0	.0%
TOTALS	168	100.0%	2110	100.0%

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Figure 3-4a. Summary of SAT Scores and Grades for Native Group

SAT Part Score	N	Mean	Standard Deviation	Range	Standard Error
Verbal	168	471.27	100.93	270-710	7.79
Math	168	482.28	99.23	260-750	7.66
SAT Total	168	953.55	172.46	550-1410	13.30
Cumulative GPA	168	2.80	.67	0-4.00	

SAT Verbal Scores Midpoints	N	Percent	Distribution
300	12	7.5%	******
350	21	13.2%	***********
400	23	14.5%	************
450	33	20.8%	******************
500	29	18.2%	****************
550	19	11.9%	**********
600	22	13.8%	************
650	4	2.5%	**
700	5	3.1%	***
750	0	.0%	

SAT Math Score Midpoints	N	Percent	Distribution
300	13	8.2%	*******
350	12	7.5%	******
400	18	11.3%	**********
450	38	23.9%	********************
500	35	22.0%	*******************
550	26	16.4%	**************
600	11	6.9%	******
650	10	6.3%	*****
700	3	1.9%	**
750	2	1.3%	*

Figure 3-4b. Summary of SAT Scores and GPA for Native Group & Population

SAT Part Score	Native N=168	Population N=2110
Verbal Mean	471.27	440.46
Math Mean	482.28	475.39
Cumulative GPA	2.80	2.556

Figure 3-5. Entering Semester of Native Group

Entering Semester	N	PERCENT
1970	2	1.2%
1971	1	.6%
1972	4	2.4%
1973	3	1.8%
1974	2	1.2%
1975	4	2.4%
1976	10	6.0%
1977	5	3.0%
1978	5	3.0%
1979	15	8.9%
1980	20	11.9%
1981	21	12.5%
1982	26	15.5%
1983	26	15.5%
1984	23	13.7%
1985	1	.6%
TOTALS	168	100.0%

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Figure 3-6. Planned Year of Graduation: Native Group

Planned Year of Graduation	N	PERCENT
No Response	13	7.7%
1966	1	.6%
1974	1	.6%
1978	1	.6%
1979	3	1.8%
1981	1	.6%
1982	1	.6%
1983	7	4.2%
1984	5	3.0%
1985	4	2.4%
1986	19	11.3%
1987	43	25.6%
1988	57	33.9%
1989	10	6.0%
1990	2	1.2%
TOTALS	168	100.0%

Figure 3-5 shows that the majority of the Native Group entered the institution in the fall 1982, fall 1983, or the fall 1984 terms. The majority of students in the Native Group reported graduation dates for a bachelor's degree either during the 1986-87 or the 1987-88 academic year (Figure 3-6). Six percent of the students planned to graduate in the 1988-89 academic year.

Students in the combined sample were clearly planning some form of post-baccalaureate study (Figure 3-7). Two-thirds (66.1%) planned to pursue a master's degree, while nearly 17 percent planned to enter a doctoral program. Only three percent had no plans for subsequent graduate study.

The educational attainment of parents has been shown to be positively correlated to student achievement in college. Nearly 31 percent of the mothers and 14.3 percent of the fathers of students had attained a high school diploma. Approximately one-tenth of both fathers and mothers had attained at least the bachelor's degree (Figure 3-8).

Figure 3-7. Degree Objectives for Georgia State Native Group

Degree Objectives	N	PERCENT
No Response	21	12.50%
Non-degree Study	5	2.98%
Master's Degree	111	66.07%
Intermediate Degree (e.g., Specialist)	3	1.79%
Doctorate (Ph.D., Ed.D.)	28	16.67%
Postdoctoral Study	0	.00%
TOTALS	168	100.00%

Figure 3-8. Educational Attainment of Parents for Georgia State Native Group

Highest Level of Education Completed	Father N	Father Percent	Mother N	Mother Percent
No Response	12	7.14%	13	7.74%
Grade School or Less	22	13.10%	12	7.14%
Some High School	21	12.50%	30	17.86%
High School Diploma or Equivalent	24	14.29%	52	30.95%
Business or Trade School	25	14.88%	15	8.93%
Some College	18	10.71%	12	7.14%
Associate Degree	10	5.95%	7	4.17%
Bachelor's Degree	17	10.12%	16	9.52%
Some Graduate/Professional School	6	3.57%	1	.60%
Graduate/Professional Degree	13	7.74%	10	5.95%
TOTALS	168	100.00%	168	100.00%

Figure 3-9. Extent of Community Service Activities for Native Group

Hours/Week in Community Service	N	PERCENT
No response	19	11.31%
0 hours	61	36.31%
1-5 hours	64	38.10%
6-10 hours	16	9.52%
11-20 hours	2	1.19%
More than 20 hours	6	3.57%
TOTALS	168	100.00%

Figure 3-10. Important Honors and Awards for Native Group

Type of Honor/Award	N	Percent
No response	18	10.71%
Student government or organization	21	12.50%
Professional (an award or prize for field work or publication of a scholarly article or book)	12	7.14%
Community service (election or appointment to a community service unit, activity, or group)	12	7.14%
Literary (editing the college paper, yearbook, or literary magazine or having a poem, story, or article published in a public paper or magazine)	18	10.71%
Artistic (a high rating in a music contest, a part in a play, opera, or show, or an award in an art competition)	13	7.74%
Athletics (a letter in athletics)	6	3.57%
None of the above categories	68	40.48%
TOTALS	168	100.00%

Over one-half (52.4%) of the combined sample students had performed some community service during the past year, but for 38.1 percent of these students this had comprised less than five hours per week (see Figure 3-9).

Over one-half (59.5%) of the sample students had earned some form of professional, community service, literary, artistic, athletics, or student government honor, or award. Prior research had shown such distinctions to be highly correlated to student performance, persistence, progress, and degree attainment in college.

Figure 3-11. Summary of Georgia State Native Group

Sample Size:	168 students
Gender:	95 females (56.5%) and 73 males (43.5%)
Race:	116 out of 168 are white (69.05%) 38 students are black (22.62%)
Major Area:	8 or more students majored in each of Accounting, Journalism, Marketing, Psychology, Information Systems, Criminal Justice, and Management
College:	7 students (4.2%) in Allied Health 69 students (41.1%) in Arts & Sciences 58 students (34.5%) in Business Administration 11 students (6.5%) in Education 23 students (13.3%) in Urban Affairs

Figure 3-11 summarizes the characteristics of Georgia State Native Group. The majority of students were majoring in programs within the colleges of Business Administration and Arts and Sciences.

IV. Determining Student Learned Abilities

GRE residual scores

To control for the effects of the incoming ability of students, the predictive effect of SAT scores were partialled from GRE item-type scores. For this, 9 GRE item-type residual scores were developed as follows:

GRE Verbal item-type residuals;

ANA:	Analogies	18 questions
SC:	Sentence Completion	14 questions
RD:	Reading Comprehension	22 questions
ANT:	Antonyms	22 questions

GRE Quantitative item-type residuals;

QC:	Quantitative Comparison	30 questions
RM:	Regular Mathematics	17 questions
DI:	Data Interpretation	10 questions

GRE Analytical item-type residuals;

ARE:	Analytical Reasoning	38 questions
LR:	Logical Reasoning	12 questions

Each of the 4 GRE Verbal item-type scores were regressed on the SAT Verbal scores. Each of the 3 GRE quantitative item-type scores were regressed on the SAT mathematics scores. Each of the 2 GRE analytical item-type scores were regressed on the SAT total scores. These GRE item-type residual scores were referred to as student residual scores, that is, the improvement students showed in general learned abilities from the time they entered college to the time of GRE testing during their senior year.

Reliability and correlation of GRE item-types

Prior to partialling the effects of the students' SAT scores from their GRE item type scores, the reliability of the GRE item-types for this sample was tested. Next, the correlation between the GRE item-types and the SAT sub-scores and total score was examined. Finally, a regression of GRE item-types on SAT sub-scores was conducted to calculate student residual scores for each GRE item-type.

A preliminary question in the analysis of GRE item-types and sub-tests is their reliability within the sample group. Three factors typically contribute to the reliability or unreliability of test scores (Ebel, 1972). The first factor is the appropriateness and definitiveness of the questions. On one hand, the appropriateness of the questions is presumed by the widespread acceptance of the GRE as an examination used in graduate school admissions. On the other hand, the appropriateness of the items and item-types may be questioned relative to the goals of the general education curriculum of the institution. In this sense, the reliability of the GRE may vary from institution to institution.

A second factor contributing to the reliability of test scores is the consistency and objectivity of the person (or in this case, machine) who scores the examinations. All the test responses are read by an optimal scanner and scored by a computer at Educational Testing Service. The accuracy of this equipment relative to the task was presumed and not tested.

A third factor contributing to the reliability is the constancy or stability of a student's ability to perform the tasks presented in the test. Students may vary from hour to hour or from day to day in their alertness, energy and recall; these may affect test performance, reducing the reliability of the scores. According to procedures established by the Educational Testing Service for the administration of the Graduate Record Examination, all students were tested on the first Saturday morning (8:00 a.m. to 12:00 p.m.) in February, of each test year.

Reliability is not merely the property of the GRE itself but rather of the individual item-types relative to the student group examined. The more appropriate the test is to the group of students, the higher the reliability of the scores. Ideally, the reliablity of a set of scores may be determined using the correlation coefficient between that set of scores and another set from an equivalent test of the members of the same group. In many testing situations, inc ing th ones described in this report, a test-retest method of determining the reliability of GRE item-types was not available.

The Guttman Split-Half method of determining reliability estimates reliability by splitting the sample into halves and determining the correlation between the scores in the two groups. The results of the split-half method are dependent upon the manner in which the group is halved. Cronbach's alpha is a statistic designed to overcome this problem. It is a generalized formula representing the average correlation obtained from all possible split-half reliability estimates.

The results of the reliability analysis for Georgia State Native Sample #1 is presented in Figure 4-1a; the reliability analysis for Georgia State Native Sample #2 is displayed in Figure 4-1b. Since different forms of the GRE were used each year, the reliability results are presented for each individual sample. For the purposes of this study, reliability coefficients at or above $\underline{a}$= .65 were deemed satisfactory (Mehrens & Lehmann, 1969). Due to the exploratory nature of this research, lower reliability coefficients were accepted. In Sample Group #1, Analogies ($\underline{a}$= .60), Data Interpretation ($\underline{a}$ = .59), and Logical Reasoning ($\underline{a}$ = .52), evidenced low reliability. In Sample Group #2, Sentence Completion ($\underline{a}$= .64), Analogies ($\underline{a}$= .53), Data Interpretation ($\underline{a}$= .47), and Logical Reasoning ($\underline{a}$= .58) showed low reliability. In both samples, the reliability of the individual item-types tended to increase with the number of items comprising the given item-type. In the cluster analytic model, the SAT sub-scores are used as measures of entering student ability. Prior to regressing GRE item-type scores on SAT scores, it is important to determine the extent to which GRE item-types and SAT sub-scores are correlated. For example, determining whether the GRE item-type, Analogies, has a stronger correlation with SAT Verbal, SAT Math or the total SAT scores will help determine which SAT score should be used in the subsequent regression analysis.

Figure 4-1a. Reliability of Coefficients of GRE Item-Types--Sample #1

GRE Item-types	Code	Number of items	Cronbach's Alpha	Guttman's Split-half
Analogy	ANA	18	.6021	.5898
Sentence Completion	SC	14	.6497	.6976
Reading Comprehension	RD	22	.7909	.6878
Antonyms	ANT	22	.8285	.8313
Quantitative Comparison	QC	30	.6714	.6607
Regular Mathematics	RM	20	.6846	.7172
Data Interpretation	DI	10	.5855	.3182
Analytical Reasoning	ARE	38	.7900	.6610
Logical Reasoning	LR	12	.5215	.4748
GRE Verbal	GRE-V	76	.9082	.9250
GRE Quantitative	GRE-Q	60	.8402	.7804
GRE Analytic	GRE-A	50	.8099	.7375

Figure 4-1b. Reliability of Coefficients of GRE Item-Types--Sample #2

GRE Item-types	Code	Number of items	Cronbach's Alpha	Guttman's Split-half
Analogy	ANA	18	.5295	.3401
Sentence Completion	SC	14	.6425	.5351
Reading Comprehension	RD	22	.6645	.4822
Antonyms	ANT	22	.7508	.6242
Quantitative Comparison	QC	30	.8067	.8255
Regular Mathematics	RM	20	.6978	.6733
Data Interpretation	DI	10	.4732	.3017
Analytical Reasoning	ARE	38	.8136	.7919
Logical Reasoning	LR	12	.5852	.5459
GRE Verbal	GRE-V	76	.8550	.6549
GRE Quantitative	GRE-Q	60	.8712	.8506
GRE Analytic	GRE-A	50	.8362	.8075

Figure 4-2 indicates strong, positive relationships between GRE item-types and SAT scores. For the Georgia State Native Sample, GRE Verbal item-types were strongly correlated to the SAT Verbal sub-score with *r* ranging from .60 to .68. GRE Quantitative item-types had strong correlations with the SAT Mathematics sub-score, *r* ranging from .52 to .72. GRE Analytic item-types evidenced strong correlations with the SAT Total score (*r* = .56 and .61). Results of the correlation analysis were comparable to those found in the other institutional samples previously analyzed (Ithaca, Mills, Evergreen, and Stanford Sample Groups).

Figure 4-2. Correlation of GRE Item-Types & SAT Scores--Georgia State Native Group

GRE Item-types	Code	SAT Verbal	SAT Math	SAT Total
Analogy	ANA	.6011	.3417	.5484
Sentence Completion	SC	.6548	.3324	.5745
Reading Comprehension	RD	.6076	.3918	.5810
Antonyms	ANT	.6807	.2632	.5498
Quantitative Comparison	QC	.3608	.7235	.6275
Regular Mathematics	RM	.3723	.6850	.6121
Data Interpretation	DI	.4033	.5224	.5367
Analytical Reasoning	ARE	.4274	.6296	.6124
Logical Reasoning	LR	.5213	.4377	.5569
GRE Verbal	GRE-V	.7852	.4069	.6937
GRE Quantitative	GRE-Q	.4371	.7860	.7081
GRE Analytic	GRE-A	.5155	.6581	.6804
Minimum		.3608	.2632	.5367
Maximum		.7852	.7860	.7081
Mean		.5306	.5149	.6068

$p < .0001$

Intercorrelation of GRE item-types

The internal validity of GRE item-types can be measured by comparing the intercorrelation coefficients of GRE item-types. In the Georiga State Native Group, the intercorrelations between GRE Quantitative item-types were relatively stronger than those between other GRE item-type scores. Each GRE subscore tended to have higher correlations with the GRE item-types constructing the subscore than with GRE item-types constructing other test subscores. The analysis of correlations among GRE item-types shows that the item-types have strong internal validity.

Wilson (1985) has suggested that GRE (and SAT) item-types may measure discrete forms of general education abilities. This assertion served as the theoretical underpinning for the use and treatment of GRE item-types as discrete, multiple measures of general learning. To test Wilson's assertion, the intercorrelation among item-type scores was further examined (see Figure 4-3).

In the Georgia State Native Group, intercorrelations for Verbal item-types ranged from $\underline{r} = .40$ (RD/ANA) to $\underline{r} = .62$ (ANT/SC). Intercorrelations for Quantitative item-types ranged from $\underline{r} = .46$ (RM/DI) to $\underline{r} = .63$ (RM/QC). Intercorrelations between Analytic item-types were $\underline{r} = .42$ (ARE/LR). However, Analytic Reasoning correlated strongly with Quantitative item-types ranging from .49 (DI) to .61 (QC). The intercorrelational analyses showed that in most instances, less than 50 percent of the variance in one item-type was explained by that of another.

Figure 4-3. Intercorrelation of GRE Item-Types for Georgia State Native Group

GRE Item-Types	Code	ANA	SC	RD	ANT	QC	RM	DI	ARE	LR
Analogies	ANA	1.0000								
Sentence Completion	SC	.6084 [4]	1.0000							
Reading Comprehension	RD	.4010 [4]	.5540 [4]	1.0000						
Antonyms	ANT	.5596 [4]	.6218 [4]	.5243 [4]	1.0000					
Quantitative Comparisons	QC	.3085 [4]	.2506 [2]	.4040 [4]	.2471 [2]	1.0000				
Regular Mathematics	RM	.3304 [4]	.2407 [2]	.3449 [4]	.2171 [2]	.6354 [4]	1.0000			
Data Interpretation	DI	.2699 [3]	.3424 [4]	.4070 [4]	.3230 [4]	.5288 [4]	.4639 [4]	1.0000		
Analytic Reasoning	ARE	.3541 [4]	.4316 [4]	.4787 [4]	.2265 [2]	.6124 [4]	.6092 [4]	.4870 [4]	1.0000	
Logical Reasoning	LR	.3967 [4]	.4606 [4]	.4724 [4]	.4449 [4]	.4472 [4]	.3213 [4]	.3709 [4]	.4187 [4]	1.0000

[1] $p < .05$ [3] $p < .001$
[2] $p < .01$ [4] $p < .0001$

As Figure 4-4 demonstrates, Georgia State Native students performed well on the GRE General Examination. Students answered the questions correctly in approximately 100 of the 186 GRE items. Some students attained perfect scores on Sentence Completion, Antonyms, Data Interpretation, and Logical Reasoning item-types.

While GRE raw scores were generally and consistently high among these students, differences among scores appeared when the effect of the precollege learning (as measured by the SAT) was removed. When the theoretical scores (as predicted by corresponding SAT scores) were compared with the students' actual responses (Figure 4-5), students showed large proportions of change on most item-types.

The greatest amount of variance in item-type residuals, including the greatest standard error and standard deviation, were found in the Analytic Reasoning and Quantitative Comparisons item-types. The variance in these residuals holds implication for the ensuing cluster analysis in that GRE item-types with greater variance will play a more significant role in sorting courses into clusters. As was discovered in the analysis of samples from other participating institutions, those GRE item-types with smaller variance play less of a role in discriminating course clusters.

As Figure 4-5 demonstrates, from one-quarter (Data Interpretation) to one-half (Quantitative Comparisons) of GRE item-type score variation among the Georgia State Native Group was explained by their SAT scores. All regression functions were statistically significant at .0001.

Using the student residuals obtained from the regression analysis above, the mean residuals for each course enrolling 5 or more students were calculated for all the 9 GRE item-types. Such a procedure does not assume that the specific gains of the students enrolled in each course were directly caused by that course. Rather, the residuals of each student are attributed to all the courses in which they enrolled, and the mean residuals for each course serve as a proxy measure of student gains. Once courses are clustered by these gains, then hypotheses can be generated and tested as to why students who enrolled in a given pattern of courses experienced significant improvement on one or more of the outcomes criteria (i.e., the item-type residuals).

Figure 4-4. The Distribution of GRE Scores for Students in the GSU Native Group

GRE Item-types	Number of Items	Minimum Right	Maximum Right	Score Range	Sample Mean	Standard Deviation
Analogy	18	3	16	13	10.26	2.5966
Sentence Completion	14	3	14	11	8.92	2.6860
Reading Comprehension	22	4	21	17	12.06	4.0516
Antonyms	22	0	22	22	10.92	4.1513
Quantitative Comparison	30	6	29	23	17.45	4.7974
Regular Mathematics	20	1	18	17	9.98	3.2665
Data Interpretation	10	1	10	9	5.14	2.0177
Analytical Reasoning	38	5	33	28	18.99	6.1508
Logical Reasoning	12	1	12	11	6.11	2.2678
GRE Verbal	76	19	70	51	42.15	10.9615
GRE Quantitative	60	13	53	40	32.56	8.6035
GRE Analytic	50	10	44	34	25.10	7.3929
GRE Verbal (converted)					474.58	102.4073
GRE Quantitative (converted)					475.83	108.9823
GRE Analytic (converted)					504.23	112.8801
Minimum	10	0	10	9	5.14	2.02
Maximum	38	6	33	28	18.99	6.15
Mean	21	3	20	17	11.19	3.67
Total	186				99.82	31.99

Figure 4-5. Summary of Regression Analysis of GRE Scores--GSU Native Group

Dependent Variables		Georgia State Native Group 168 Students		
GRE Item-types on SAT Sub-scores	Code	F Value	Standard Deviation	Adjusted R-Squared
Analogies	ANA	93.910	2.5966	.3575
Sentence Completion	SC	124.610	2.6860	.4253
Reading Comprehension	RD	97.122	4.0516	.3653
Antonyms	ANT	143.335	4.1513	.4601
Quantitative Comparisons	QC	182.350	4.7974	.5206
Regular Mathematics	RM	146.754	3.2665	.4660
Data Interpretation	DI	62.317	2.0177	.2686
Analytic Reasoning	ARE	99.616	6.1508	.3713
Logical Reasoning	LR	74.640	2.2678	.3060
Verbal (raw)		266.909	10.9615	.6142
Quantitative (raw)		268.383	8.6035	.6155
Analytical (raw)		143.057	7.3929	.4596

$p > F = .0001$

Regression analysis of SAT scores on GRE item-type scores

To determine the extent to which these students showed improvement over their precollege SAT scores the GRE raw scores were regressed on the corresponding SAT scores. GRE Verbal item-types were regressed on SAT Verbal sub-scores, GRE Quantitative item-types were regressed on SAT Math scores, and GRE Analytic item-types were regressed on SAT Total scores. The resulting GRE item-type correlations with corresponding SAT scores were noticeably lower than their corresponding GRE sub-scores. This suggests that individual item-types also may measure discrete abilities apart from those of the SAT sub-scores and/or they may reflect lower reliability stemming from the fact that there are fewer items comprising an item-type than a sub-score.

The SAT scores explained smaller portions of variance in GRE item-type scores than in the GRE sub-scores (Verbal, Quantitative and Analytical--see Figure 4-5). The SAT Verbal explained 42.53 percent of the variance in the Sentence Completion item-type among the Georgia State Native Group. The SAT Verbal explained 35.75 percent of the variation in the Analogies item-type, 36.53 percent of the variation in Reading Comprehension and 46.01 percent in Antonyms items among the Georgia State Native Group. The SAT Math scores explained 52.06 percent of variation in Quantitative Comparison item responses, 46.60 percent of variation in Regular Math item-type scores, and 26.86 percent of variation in Data Interpretation for the Georgia State Native Group. The combined SAT Verbal and SAT Math scores (referred to as SAT Total) explained 37.13 percent of variance in Analytic Reasoning and 30.60 percent of variance in Logical Reasoning for the Georgia State Native Group. In all instances, the regression model proved significant at the .0001 level, suggesting effective control measures for the general learned abilities of students as they entered college as freshmen.

Georgia State Native Group students entered college with slightly higher mean SAT Math score (482.3) than SAT Verbal score (471.3). As these Georgia State Native students approached graduation, they remained normatively stronger in Quantitative abilities (mean GRE-Q = 476) than in Verbal abilities (mean GRE-V = 475). Yet, the regression analysis showed the Georgia State Native students evinced large variance in residuals on specific GRE item-types in excess of those represented in the sub-scores of the two tests. For Georgia State Native students, specific and significant residual variance was demonstrated in Quantitative Comparison and Analytic Reasoning.

Figure 4-5 compares the explained variance (R-squared) for each GRE item-type, raw GRE sub-score and converted GRE sub-score. Only SAT sub-scores were available to the research team; these scores are converted scores. The actual scores of a student on a particular form of the SAT test is transformed relative to test norms so as to be comparable with other forms of the test and with other students tested. A similar process is used with the GRE exams. Raw GRE sub-scores for a given form of the test are transformed so as to allow comparisons with national norms and with scores on other forms of the test. In all cases within the Georgia State Native Group, the SAT accounted for more variance in GRE sub-scores than in the GRE item-type scores. Figure 4-6 illustrates the extent of unexplained variance (that is, the variance in GRE item-type scores attributable to sources other than the precollege abilities of the students, as measured by the SAT). Only the converted GRE sub-scores are graphed in Figure 4-6. The findings tend to agree with previous reports of this project and those by Wilson (1985) suggesting that GRE item-types may have greater correlation with variance in learning during the college years than do the GRE sub-scores.

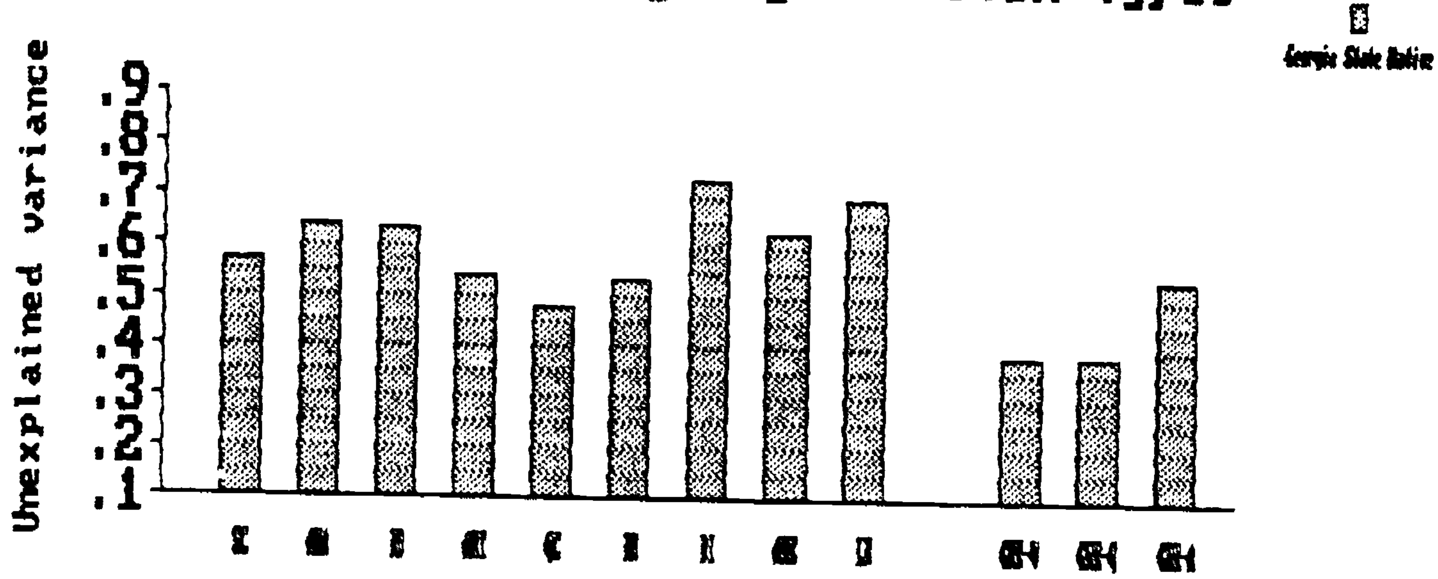
As has been previously discussed, critics of the GRE and SAT as measures of general learned abilities attack the validity of the measure themselves. These criticisms are based primarily on the use of the test sub-scores and the total test scores; the use of the item-type scores on either the GRE or SAT as multiple measures of general learning have not been widely explored (Adelman, 1988). The reliability of GRE item-types, their strong correlation with SAT sub-scores, and their apparent ability to measure discrete types of learning suggest that they may be of potential value as criteria in the assessment of general learning abilities of undergraduates.

For the purposes of this research, precollege measures of student ability were defined as the SAT-V, SAT-M, and the total SAT score. Although there is research to suggest that SAT item-types may have greater predictive validity of college performance (Ramist, 1981a; 1981b; Schrader, 1984), SAT item-types were not available for use in the research model. Postcollege measures of student learning were defined as the 9 item-type scores on the GRE. According to Astin's model (1970a, 1970b), the effect of the learned abilities of students entering college on student outcome measures should first be determined. Once the variance in GRE item-type scores attributable to SAT scores was determined, the unexplained variance (score residuals) could be used as a proxy of change in general student learning along the 9 item-type measures.

The SAT Verbal scores were used to predict each of the GRE Verbal item-types using the general lineal model. The SAT Math scores were used to predict each of the corresponding GRE Quantitative item-types. The combined SAT scores (SAT Total) were used to predict the GRE Analytic Scores. The regression analysis summarized in Figure 4-5 was performed by the PROC REG in the SAS statistical package. Individual student score residuals theoretically ranged from +1.00 to -1.00. Since individual scores were predicted relative to the combined sample group, some students will have higher actual scores than predicted scores, while others will have lower actual scores than predicted scores. A negative residual represents the unexplained variance of a student whose actual GRE item-type score was less than that predicted by the student's corresponding SAT subscore. Larger unexplained variance on a given item-type indicated larger amounts of change (either gain or loss) in general learned abilities associated with that measure.

Variation in GRE item-type scores may be attributed to two sources: variation due to changes in the independent SAT variable and changes attributable to other sources. In all cases in the Georgia State Native Group, the probability of obtaining the F value was .0001, suggesting that the general linear model is adequate in explaining the sources of variation within the GRE item-type scores. R-squared represented the percent of total GRE item-type variation explained by the independent SAT variable. The residual variation in each GRE item-type--that not measured by the SAT score--was used as the proxy measure of general learned abilities during the undergraduate experience. These student residual scores, from the time they took the SAT prior to college to the time they took the GRE as graduating seniors on each of the 9 item-types, served as the measures of general learning among the Georgia State Native Group (Hanson, 1988; Pascarella, 1987).

Fig 4-6. Change by GRE item-types



and GRE sub-scores

V. Review of Literature on Catalogues

The purpose of the GSU Catalogue studies was to describe the intended curriculum in general education for undergraduates. By examining the nature, scope, and structure of the curriculum, constraints to students' course-taking behavior may be identified. Furthermore, the catalogue studies provided a comparative basis for examining what the enrollment patterns of students who showed gains in general learning were in relation to what the college intended the curricular patterns in general learning to be. Such an examination was admittedly a comparison of local requirements (general education degree requirements) with national norms of general learning as measured by the GRE examination.

The GSU Catalogue studies began with a review of pertinent prior research. The issues and procedures identified in previous studies guided the inquiry. The review of selected research in which college catalogs served as sources of curricular data and analysis revealed three basic avenues of investigation. The first used catalogs to analyze the development of a specific academic area or topic. The second avenue of research employing catalogs studied change in the general education curriculum which occurred over a specific time period. The third research area involved the use of catalogs to develop course classification systems.

Catalog studies of specific academic areas

Becan-McBride (1980), Boysen (1979), Fosdick (1984), LoGuidice (1980), and Tenopir (1985) used catalogs to study the status of particular academic areas. Two other studies (Gillespie & Cameron, 1986; Grave, 1985) used catalogs to analyze the development of a specific academic discipline over time.

Boysen (1979) analyzed the undergraduate technical communications curriculum at selected colleges of engineering. Institutions were chosen for inclusion in the study based on the clarity of written course and program descriptions found in the college catalogs. Boysen's study showed that many catalogs are replete with ambiguities and that generalizations of curricular comparability may be drawn only to those institutions with clearly written catalogs.

Becan-McBride (1980) used the catalogs and brochures from medical technology programs to study characteristics such as course requirements, nature of the program, degree earned, and accreditation. The study found that different types of medical technology programs mandated different prerequisites, thereby impacting on course-taking behavior evidenced on student transcripts.

LoGuidice (1983) analyzed the catalogs of Lutheran-affiliated colleges and universities to determine the presence of a global/international curricular perspective. Course titles and course descriptions were examined for certain key words and phrases selected *a priori*. LoGuidice found descriptive commonalities across like departments or disciplines, with some phrases appearing more frequently in certain programmatic areas.

The purpose of Fosdick's research (1984) was to determine the educational impact of information science on library science curricula. Catalog course titles and descriptions were used as data sources because Fosdick believed them to be more objective than verbal or written questionnaires. He found, however, several problems seemingly inherent in catalog research: "... investigation of the catalogs does involve the subjective judgments of the surveyor, and a few schools do not provide adequate information in their catalogs on which to base an appraisal ..." (p. 293).

Tenopir (1985) studied the kinds of college courses used to determine a specialization in information science through an analysis of course descriptions, course titles, and/or department titles. Based on this descriptive information, courses were assigned to one classification category. Originally selected to provide an unobtrusive means of data collection, Tenopir found that the lack of common nomenclature in college catalogs made the study difficult and time consuming. While many of the same courses existed within all parent departments, most did not include the word "information" in their title making initial departmental identification problematic.

Grace's study (1985) examined the context of higher education administration curricula in order to determine the extent of professionalization within the field. She used college catalogs from 1972-73 and 1982-83 to gather and compare information on the total number of program hours required, and the number of recommended courses within and outside higher education. Grace also included program handbooks and student transcripts in her data collection in order to be able to address the issue of intended curricula versus actual course taking behavior.

Gillespie and Cameron (1986) used college catalogs, textbooks, and national convention programs to determine the development of the teaching of acting in colleges and universities over a forty-year time period. In order to delineate appropriate courses for inclusion in the study, Gillespie and Cameron chose only those courses in which the word "acting" or a variation of "acting" appeared in the course title or description.

From these studies, it appears that college catalogs can be useful in examining the status of specific academic areas or their development over time. In each case, while other sources may have been included, the primary data were derived from an analysis of course titles and/or course descriptions found in the college catalogs. However, the studies also revealed several weaknesses inherent in the use of catalogs (particularly course titles) as primary data sources. The ambiguity of the catalogs themselves as well as the varying vernacular intra- and interinstitutionally make data gathering difficult and time consuming, and analysis more subjective than it at first appears. These issues are not mitigated by the use of a priori designations which, while common in the reviewed research, often necessitate judgmental categorizations. Multiple data sources including student transcripts may therefore be important to future curricular research, especially when attempting to understand the intended versus actual curriculum.

Studies of catalog change over time

Four studies, Hefferlin (1969), Dressel and DeLisle (1969), Blackburn, Armstrong, Conrad, Didham, and McKune (1976), and Toombs, Fairweather, Amey, and Chen (1989), used college catalogs to examine broader higher education curricular issues. Hefferlin studies curricular change based on expansion and reform over a five-year period. He used five areas of the catalog as data sources: program majors, areas of concentration, requirements within majors, degree requirements for graduation, and general curricular regulations. Hefferlin developed the Study of Institutional Vitality (SIV) model for analyzing curricular reform by calculating the proportion of courses that were dropped or noticeably changed in departments where the number of courses increased. Reform was also calculated by the proportion of courses added or changed in departments where the number of courses increased. Reform was also calculated by the proportion of courses added or changed in departments where the number of courses had decreased. Hefferlin found that expansion occurred more frequently in upper division courses than in lower division, and that curricula at state colleges expanded more than at any other institutional type. The general education component remained stable during the study period and the proportion of the curricula devoted to the academic major increased.

The other three studies focused primarily on the status and changes in general education curricula over time. Change was basically determined on the basis of breadth and depth, breadth being defined as the percentage of course requirements represented by general education, and depth as the percentage represented by the academic major.

Dressel and DeLisle (1969) studied 322 college and university catalogs to determine change over the ten-year period from 1957-67. They found a decline in the specificity of general education requirements, a wide variation in the course and credit requirements for academic majors, and an increase in the proportion of elective courses permitted in fulfilling degree requirements. Part of this latter increase seemed tied to the simultaneous emergence of more individualized student learning experiences such as honor programs, advanced placement courses, and study abroad programs.

The study by Blackburn et al. (1976) was, in part, designed to replicate the work of Dressel and DeLisle, examining the status of undergraduate education between 1967 and 1974. Using a slightly smaller sample (271), this study found that the proportion of general education courses required for a degree decreased during this timeframe while the proportion of coursework devoted to the major changed very little. This resulted in a net gain in the elective course area. Using transcript analysis, Blackburn et al. went on to examine the course-taking behavior of students during this same time period as compared to degree requirements evidenced in the catalogs. Again, though the sample included in the transcript analysis was very small, the study found a high level of congruence between stated degree requirements and student course-taking behavior. The researchers concluded that there was a need to examine the relationships between different teaching techniques, curricular programs, and different learning outcomes.

Toombs et al. (1989) sought to show change in the general education curricula since the Blackburn study. Their research involved an analysis of data from 700 1986-87 college and university catalogs including degree, general education, and major requirements as well as descriptive information found in curricular mission statements. The research showed an increase in the proportion of the curriculum devoted to general education since the 1976 study, while the total credits for a baccalaureate degree remained stable. The increase primarily occurred through an expansion of technical course requirements such as writing, speech, computer and quantitative reasoning; little increase was found in humanities, social sciences, and nature sciences.

Each of the preceeding studies acknowledged the difficulties in using catalogs as primary data sources described by Dressel and DeLisle in the 1960's. Catalogs are often poorly organized, inaccurate, ambiguously written, and intra- and interinstitutionally inconsistent. Hefferlin's SIV model, Blackburn's transcript analysis, and Toombs' sample size and descriptor analysis can all be seen as ways of methodologically improving studies using catalog data. The use of transcript analysis, while making the most viable connections between theory (catalog data) and practice (evidence of student course-taking behavior), also proved to be slow and expensive.

Studies of course coding and classification

Two fairly recent studies used college catalogs in the development of course classification systems at the state and national levels. Waggaman (1980) examined the effect of various forms of credit and non-credit designations on the Florida Statewide Course Number System (SCNS). The significant variation that existed made it difficult to administer student credits when transferring from one Florida institution to another. Waggamon studied catalogs, various state and federal laws, and accreditation documents from professional organizations. This analysis led to an examination of past and present credit practices in Florida as well as recommendations for specific policies to reduce the existing problems in course classifications by level and department.

On a national level, the Classification of Secondary School Courses project (NCES, 1982) used course descriptions collected from high school catalogs to develop a nationwide inventory of secondary school courses. A panel of reviewers examined the catalogs and established a course title index for each course, a unique 6-digit code number, keyword descriptors, and alternate course titles. The director was designed to be used by NCES for coding high school transcripts.

Discussion and results of the literature review

Several themes emerge from this literature review relevant to the use of catalogs as primary data sources for studying the curriculum. The studies suggest that, when studying curricular change especially theory to practice, it is necessary to include multiple data sources. This may simply involve utilizing various sections of a college catalog, for example mission statements and course descriptions in addition to course titles and degree requirements. Increasing the sample size or using catalogs from several academic years can be useful in studying breadth and depth of curricular issues. Student transcripts can add a comparative perspective between intended and actual curricula. A careful reading of the catalog must still be included, however, to identify prerequisites, number of courses required or recommended within and outside a field of study--all of which effect course-taking behavior but which may not be easily differentiated when using transcripts alone. The studies indicate that college catalogs, especially in conjunction with other data, can also be used to demonstrate change in academic departments, general education, and the proportional relationships of curricular components at programmatic and institutional levels.

From a methodological perspective, common research designs were used in the studies discussed above. Generally, these studies used predetermined categories of courses established de novo or derived from previous research. Simple word counts or qualitative content analyses of course titles and/or descriptions were used to determine placement within each category, but there was no evidence that formal procedures were used to examine the content or concurrent validity of the categories themselves. Furthermore, ambiguities and inconsistencies in wording made it difficult to assign courses to predetermined categories or to identify comparable programs. In response, some researchers erected more discrete and exacting operational definitions upon which to judge and classify courses. Even with these more stringent attempts, there remain questions as to the validity and reliability of classifications which depend on clearly worded course titles and descriptions, as well as questions regarding inter-rater reliability in categorizing the data. Since a major attraction of catalogs as primary data sources has been their objectivity and accessibility, it is important to recognize the researcher subjectivity inherent in collecting and analyzing catalog information.

Structure and Content of General Education Requirements at GSU

All the students in the Georgia State Native Samples began and completed their educational program at Georgia State University. Undergraduate coursework at GSU is structured according to the institutional mission and by the baccalaureate degrees offered. The study of GSU catalogs from 1983-84 to 1987-88 began with an examination of institutional mission and undergraduate degree requirements.

The Carnegie Classification scheme provides a means for placing all colleges and universities within a comprehensive categorization system of six institutional types ("Carnegie Foundation," 1987). According to this typology, Georgia State University is a public doctorate-granting institution. To fulfill its threefold mission, it promotes the advancement of knowledge through excellence in teaching, research, and public service. The institution's mission focuses on developing in students the requisites for competence, personal fulfillment, and responsible leadership in business and the professions, in the sciences, in the creative and performing arts, in government and in public service.

Georgia State University has five colleges that offer undergraduate degrees: Arts and Sciences, Business Administration, Education, Health Sciences, and Public Affairs. The University requires each student seeking the baccalaureate degree to complete satisfactorily a general education component. Included in this section are the course numbers listed in the 1986-87 and 1987-88 GSU catalogs which constitute the requirements relative to the breadth of the curriculum (Blackburn et al., 1976). The purpose of this part of the catalog study was to identify the minimum general education requirements of each degree offered by the University. For each degree there are other requirements (listed as Areas IV, V, VI, and VII) which specify depth (major concentration) requirements which are not listed here.

Distribution requirement

The exact nature of the general education core requirement varies somewhat by college and degree. This basic core of general education subjects includes 60-80 quarter hours of coursework and is drawn from three customary groupings of disciplines: Area I: Humanities, Area II: Mathematics and Natural Sciences, and Area III: Social Sciences. All colleges conform to the distributional pattern of general education requirements, with minor variations, that follows:

Core Area I--**HUMANITIES**. Analysis of the humanities requirements suggests a tendency to require courses or competencies in English 111, 112, 113 to complete the composition aspect of the Core Area I requirement. Speech 150 and Philosophy 241 tend to be recommended although any 100 or 200 level English course can be chosen to complete the remainder of the requirment. The fine arts are also included to represent the practice and trends in the whole field of the humanities. Two other humanities options that appear are Art History 170, 175, 180, and Music 161, 193/393.

There is no requirement for demonstration of a proficiency level in a foreign language sequence, although the catalog offers classical and modern foreign language sequences in Arabic, Dutch, French, German, Greek, Hebrew, Italian, Japanese, Latin, Russian, Scandinavian, and Spanish. Reference to the Department of Foreign Languages accounts for additional courses that may be taken to fulfill the 20 quarter hour humanities requirement.

Core Area II--**MATHEMATICS AND NATURAL SCIENCES**. Only the Bachelor of Business Administration and the Bachelor of Social Work specify a requirement of mathematics and natural science to be met. A prevailing pattern of a 10-hour sequence in a laboratory science tends to accompany a general natural science requirement. The widely varying practices exhibited in the choices of Mathematics and Natural Sciences courses are represented in selections from Astronomy 101, 102, Biology 141, 142, Chemistry 101, 102, Computer Science, Decision Sciences 104, 122, Geography 103, 104, Geology 101, 102, Mathematics 107, 211, 212, and Physics 101, 102. There is some ambiguity as to what is included in the sciences. On this point, geography is included among the alternatives available in the social sciences distribution requirements.

Core Area III--SOCIAL SCIENCES. History 111 and 112 are prominent among the social sciences requirements, either as an alternative to or an equivalent of History 113. Political Science 101 is a requirement in the Bachelor of Social Work degree and Political Science 201 is required for the Bachelor of Business Administration. Occasionally specific reference is given in the degree requirements to behavioral science electives. Among the available options in the social sciences distribution requirements, two courses may be selected from the following: Anthropology 201, 202, 203, Economics 210, Geography 101, 205, Philosophy 101, 202, 203, 204, or Sociology 201, 202.

The general education requirements attach some importance to the level of the course. With the exception of the dual listed MUS 193/393 in the GSU catalog, no 300 or 400- level courses are listed. Figure 5-1 reveals either the increased availability of 100-level courses or a preference of students to complete their core requirements within the 100-level. Requirements in Core Area II are primarily fulfilled through freshman level 100 courses, as the percentages reveal. In contrast, slightly less than two-thirds of the courses identified for Core Area III, Social Sciences, requirements are sophomore level in the GSU catalog, yet less than half of the courses taken are sophomore level. There is an even distribution of Core Area I, Humanities, requirements between freshman and sophomore level courses in the GSU catalog, but again the preference is for the freshman level. Courses intended to develop students' quantitative abilities are clearly lodged in the freshman year experience, while courses intended to develop verbal abilities are distributed evenly across the lower division of the curriculum. No junior or senior level course is specifically identified as contributing to the general education of GSU students.

Figure 5-1. Distribution of core areas by level of GSU transcript courses.

	Freshmen 100 Level	Sophomore 200 Level	Total Courses
Core Area I. Humanities	532 70.1%	227 29.9%	759 100.0%
Core Area II. Mathematics & Natural Sciences	591 83.2%	119 16.8%	710 100.0%
Core Area III. Social Sciences	642 56.1%	502 43.9%	1144 100.0%
Total	1765 67.5%	848 32.5%	2613 100.0%

Variation and Change in the GSU Catalogs

The final step in the GSU study involved looking for variance in the curriculum by examining catalogs from the 1983-84 academic year through the 1987-88 academic year. The courses selected to represent the curriculum during this period were those unduplicated courses taken by the students in the Georgia State Natives Combined Sample. The total number of courses examined was 1080.

For each course a determination was made as to whether the course appeared in each catalog within the time frame indicated and a notation was made. Courses dropped from the curriculum and departmental code changes were also noted. Simple frequencies of these changes were then tabulated.

During the time indicated the Department code initials for four departments changed in the GSU catalog. In the 1982-83 GSU catalog Drama (DRAM) courses became Theater (TH) or Film (FILM)courses. Information Systems (IS) courses became Computer Information Systems (CIS) courses in the 1984/85 GSU catalog. Also, it was noted that in the 1986-87 GSU catalog the Art courses were listed under sub-specialties of Art such as drawing, crafts, sculpture, etc. An example would be that a drawing and/or painting course now has a listing of DP rather than ART, even though the course is still offered through the Art Department. In the same catalog the departmental codes for the college of Education also underwent a total revision. When these changes occurred, it appeared that there was also an increase in the number of courses offered in the revised areas.

Within the time frame under investigation, there were ninety-seven course title changes noted in the GSU catalogs. These were cases where the course listing and course number remained the same, yet the title was simply altered. It cannot be determined from a catalog study whether all title changes reflect true change in course content or whether the title was changed to more accurately reflect what was being taught in the courses.

As Figure 5-2 illustrate, most of the curricular change occurred during two years, 1984-85 and 1986-87. The total number of course additions and deletions represented no greater than 6.98 percent for any one year (1984-85) and no more than 20.63 percent cumulative change since the 1982-83 academic year. These findings suggest a small amount of variability in the curriculum over the time period studied. Unlike the conclusions of earlier catalog studies (Blackburn <u>et al.</u>, 1976; Dressel and DeLisle, 1969; Hefferlin, 1969), the rate of curricular change at GSU during the period studied was not rapid. The assumption that course content and curricular content remained basically stable over time appeared to be confirmed.

Figure 5-2. Curricular change in GSU College catalogs, 1983-1988.

GSU Catalog	Course Additions	Course Deletions	Total Change	Net Change	Total Courses	Percent Change
1983-84	30	11	41	19	1080	3.80%
1984-85	65	14	79	51	1131	6.98%
1985-86	20	15	35	5	1136	3.08%
1986-87	29	26	55	3	1139	4.83%
1987-88	8	14	22	-6	1133	1.94%
TOTALS	152	80	232	72	1133	20.63%

Figure 5-3 reveals the changes in GSU departmental programs. Certain departments evidenced a high number of curricular additions. For example, Computer Science (CSC), English (ENG), Journalism (JOUR), and Music (MUS) departments had substantial additions as well as the most net curricular change. Given Hefferlin's hypothesis (1969) that high frequency of curricular change occurs in environments of institutional instability and that low frequency of curricular change occurs in environments of institutional stability, further research may be warranted to determine if the hypothesis is applicable to different levels of the organization such as departments. Did faculty and staff in the departments with a high degree of net change sense greater departmental instability and disarray in the years preceding the catalog changes? Did faculty and staff in comparably sized departments with low curricular change experience greater levels of departmental stability? Such questions are beyond the scope of the current research project, but may warrant investigation by other researchers.

Figure 5-3. Curricular change by GSU department

Dept Code	Additions Num	Additions %	Deletions Num	Deletions %	Total Changes Num	Total Changes %	Net Change Num	Net Change %
AC	7	4.6%	4	5.3%	11	4.8%	3	4.0%
ART	6	4.0%	17	22.4%	23	10.1%	-11	-14.7%
ANTH	2	1.3%	5	6.6%	7	3.1%	-3	-4.0%
AS	5	3.3%	0	.0%	5	2.2%	5	6.7%
ASTR	0	.0%	0	.0%	0	.0%	0	.0%
AVI	0	.0%	0	.0%	0	.0%	0	.0%
BA	1	.7%	0	.0%	1	.4%	1	1.3%
BED	6	4.0%	2	2.6%	8	3.5%	4	5.3%
BL	0	.0%	1	1.3%	1	.4%	-1	-1.3%
BIO	2	1.3%	2	2.6%	4	1.8%	0	.0%
CHEM	3	2.0%	4	5.3%	7	3.1%	-1	-1.3%
CIS	0	.0%	1	1.3%	1	.4%	-1	-1.3%
CJ	9	6.0%	0	.0%	9	4.0%	9	12.0%
CM	3	2.0%	0	.0%	3	1.3%	3	4.0%
CSC	8	5.3%	0	.0%	8	3.5%	8	10.7%
DEC	1	.7%	1	1.3%	2	.9%	0	.0%
DM	0	.0%	5	6.6%	5	2.2%	-5	-6.7%
DRAM	2	1.3%	0	.0%	2	.9%	2	2.7%
DSC	4	2.6%	0	.0%	4	1.8%	4	5.3%
EC	3	2.0%	1	1.3%	4	1.8%	2	2.7%
ECI	1	.7%	0	.0%	1	.4%	1	1.3%
EMC	1	.7%	0	.0%	1	.4%	1	1.3%
ENG	10	6.6%	3	3.9%	13	5.7%	7	9.3%
FED	0	.0%	0	.0%	0	.0%	0	.0%
FI	0	.0%	0	.0%	0	.0%	0	.0%
FOLK	0	.0%	0	.0%	0	.0%	0	.0%
FR	3	2.0%	1	1.3%	4	1.8%	2	2.7%
GEOG	4	2.6%	1	1.3%	5	2.2%	3	4.0%
GEOL	0	.0%	3	3.9%	3	1.3%	-3	-4.0%
HIST	1	.7%	0	.0%	1	.4%	1	1.3%
HPRD	4	2.6%	0	.0%	4	1.8%	4	5.3%
HRTA	5	3.3%	0	.0%	5	2.2%	5	6.7%
ILLU	3	2.0%	0	.0%	3	1.3%	3	4.0%
IS	0	.0%	0	.0%	0	.0%	0	.0%
JOUR	12	7.9%	6	7.9%	18	7.9%	6	8.0%
JPN	0	.0%	0	.0%	0	.0%	0	.0%
LGLS	0	.0%	2	2.6%	2	.9%	-2	-2.7%
LSM	0	.0%	1	1.3%	1	.4%	-1	-1.3%
MATH	2	1.3%	2	2.6%	4	1.8%	0	.0%
MGT	1	.7%	1	1.3%	2	.9%	0	.0%
MH	3	2.0%	2	2.6%	5	2.2%	1	1.3%
MK	1	.7%	0	.0%	1	.4%	1	1.3%
MT	0	.0%	0	.0%	0	.0%	0	.0%
MUS	11	7.3%	4	5.3%	15	6.6%	7	9.3%
NTD	1	.7%	0	.0%	1	.4%	1	1.3%
NURS	6	4.0%	4	5.3%	10	4.4%	2	2.7%
PHIL	3	2.0%	0	.0%	3	1.3%	3	4.0%
PHYS	0	.0%	0	.0%	0	.0%	0	.0%
POLS	3	2.0%	0	.0%	3	1.3%	3	4.0%

PSY	1	.7%	0	.0%	1	.4%	1	1.3%
PT	2	1.3%	0	.0%	2	.9%	2	2.7%
RE	0	.0%	0	.0%	0	.0%	0	.0%
RMI	0	.0%	0	.0%	0	.0%	0	.0%
RTP	0	.0%	0	.0%	0	.0%	0	.0%
SPAN	4	2.6%	1	1.3%	5	2.2%	3	4.0%
SOC	1	.7%	1	1.3%	2	.9%	0	.0%
SPCH	0	.0%	0	.0%	0	.0%	0	.0%
SW	1	.7%	0	.0%	1	.4%	1	1.3%
TH	0	.0%	1	1.3%	1	.4%	-1	-1.3%
US	5	3.3%	0	.0%	5	2.2%	5	6.7%
Totals	151	100.0%	76	100.0%	227	100.0%	75	100.0%
Average	2.5	1.7%	1.3	1.7%	3.8	1.7%	1.3	1.7%
Maximum	12	7.9%	17	22.4%	23	10.1%	9	12.0%
Minimum	0	.0%	0	.0%	0	.0%	-11	-14.7%
Std Dev	3.0	2.0%	2.6	3.4%	4.6	2.0%	3.1	4.2%

Findings and conclusions from the GSU catalog study

Like previous studies (Boysen, 1979; Dressel & DeLisle, 1969; Fosdick, 1984; Tenopir, 1985), the GSU catalog study encountered difficulty in placing courses into the predetermined categories and identifying like programs. Often judgments needed to be made on the basis of catalog descriptions as to whether a course had undergone substantial revision, was equivalent to a course appearing in a previous catalog under a different number and/or department, or was cross-listed with a course in another department. It was also ambiguous to whether certain courses were recommended or required to meet the general education core requirements of the various degrees at GSU College. In short, ambiguities in wording and phraseology made the catalog analyses difficult. Research on inter-rater reliability in such catalog analyses is needed. However, the catalog study was necessary and essential in order to compare and contrast the similarities and differences between the intended general education (as stated in the catalog) with the actual general education of students (as evidenced on their transcript.

The review of the prior catalog studies identified several methodological and substantive issues. First, prerequisites appeared as variables posing potentially significant constraints on course-taking behavior (Becan-McBride, 1980). The GSU Catalog Study indicated a low percentage of course prerequisites had been ignored. This suggested that students were constrained in their course-taking behavior by course prerequisites.

A second issue discussed in the prior catalog studies was that course content may exhibit commonalities across institutions by academic department or program (Dressel and DeLisle, 1969) and among institutions by type (Becan-McBride, 1980; Boysen, 1979; LoGuidice, 1983; Tenopir, 1985). However, general education requirements may be subject to broader social and intellectual trends and may vary regardless of institutional type (Dressel and DeLisle, 1969). These observations required interinstitutional comparisons of general education requirements and of the content and distribution of courses within departments. Such analyses require comparable catalog studies of the other institutions participating in this project. Since there is but one institution per Carnegie classification ("Carnegie classification", 1987; Ratcliff, 1986), comparisons of catalog content within a given type of institution were not possible within the scope of the current research project.

Prior literature had suggested that the number of hours required of a specific program, the number of recommended and the number of required courses within a field of study and outside a field of study were also found to be potential constraints on study course selection and enrollment (Dressel and DeLisle, 1969; Grace, 1985). The general education requirements for the baccalaureate degrees offered by the colleges of GSU varied considerably in their prescriptivity, suggesting that course enrollment patterns may vary by degree and college. Such variation and its impact on GRE item-type residual scores will be explored in subsequent reports.

Specific subjects or departments were identified in the GSU general education requirements for one or more of the bachelors degrees. The courses within the Department of Mathematics were generally prescribed or recommended to meet Core Area II of the GSU general education requirement. The inclusion of mathematics courses in coursework patterns found by cluster analysis of student transcripts not only tended to confirm the prescription of mathematics courses, but also suggested which of those courses students who performed well on the GRE quantitative item-types enrolled.

There appeared to be some contradictions within the GSU general education requirements. Specifically, PHIL 201 and AH 170 and AH 175 were applicable to Humanities (Core Area I) in one instance and to Social Science (Core Area II) in another. Appearance of these courses within coursework clusters associated with high gains in verbal abilities would affirm the notion that students choosing these courses often also perform well on those sections of the GRE traditionally associated with the Humanities. Similarly, appearance of these courses in clusters related to analytic reasoning may suggest relationships with either the Humanities or Social Sciences.

Particular value was placed on laboratory science courses taken in a sequence in meeting the GSU general education requirements for Natural Science (Core Area II). The appearance of these specific laboratory course sequences in the coursework patterns will be examined.

The GSU Catalog Study revealed that the intended undergraduate general education was primarily (but not exclusively) confined to freshman and sophomore (100-200 level) courses. Analysis of the distribution of courses by level appeared warranted for the coursework patterns analysis.

The above findings and observations from the GSU Catalog provide a basis for making comparisons between the <u>intended</u> curriculum and the enrollment patterns of the GSU Native Combined Samples. In the following Chapter, the results of the quantitative cluster analysis of GSU coursework is presented. The results are then contrasted with the findings of the GSU Catalog Study.

VI. Quantitative Cluster Analysis of Georgia State Native Combined College Sample

Overview

This section reports the use of the quantitative cluster analytic procedure to analyze the Georgia State Native Group. The findings from the analysis of the combined Sample #1 and Sample #2 Native students is presented. The objects of these analyses are the courses which constitute the enrollment patterns of students in the Georgia State Native Group. The demographic profile of these Georgia State Native students was presented in Section 3. In Section 4, the distribution of GRE and SAT scores was presented. Also in that Section, some basic information on the distribution of courses on the students' transcripts was also presented. The subject of the overall research is the coursework in which students enrolled, not the students themselves. The criterion variables in the research are the GRE item-type residuals. The distribution of those residuals among the coursework is described below.

Georgia State Native Student Group

There were 7,850 courses listed on the 168 transcripts of the students in the Georgia State Native Group, indicating that, on average, each of these students had enrolled in 46.7 courses as part of the baccalaureate degree program. There were 1,244 unduplicated courses on the Native transcripts, 300 in which 5 or more students had enrolled. These 300 courses were the objects of further analysis. Certain departments predominated in those enrollment patterns. Looking at the total (duplicated) course count of 7,850, 25 departments had their courses appear 100 times or more on the student transcripts. The 100 or more duplicated courses were taken from each of the following departments:

Department Code	Course Count (Duplicate)	Department
AC	341	Accounting,
ART	153	Art,
BIO	241	Biology,
CHEM	168	Chemistry,
CIS	112	Computer Information Systems,
CJ	133	Criminal Justice,
DM	120	Decision Mathematics,
DS	178	Developmental Studies,
DSC	144	Decision Sciences,
EC	263	Economics,
ENG	765	English,
FR	119	French,
HIST	375	History,
IS	100	Information Systems,
JOUR	165	Journalism,
MATH	525	Mathematics,
MGT	215	Management,
MK	167	Marketing,
MUS	352	Music,
PHIL	176	Philosophy,
POLS	277	Politics,
PSY	301	Psychology,
SOC	260	Sociology,
SPAN	129	Spanish,
SPCH	120	Speech.

English was clearly the department of most frequent enrollment.

Figure 6-1 shows that the lower division (61.20%) leads the upper division (38.80%) in enrollment, as demonstrated on the transcripts.

Figure 6-2 shows that the courses on the transcripts were taken by some students over a period of years. Twenty-two percent of the students enrolled in coursework from 1970 to 1981. These students were non-traditional and likely proceeding on a part-time basis.

Figure 6-1. Distribution of courses by course numbering

Course level	Frequency	Percent	Cumulative Percent
100-199	3,141	40.01%	40.01%
200-299	1,663	21.18%	61.20%
300-399	1,684	21.45%	82.65%
400-499	1,341	17.08%	99.73%
500-599	21	.27%	100.00%
TOTALS	7,850	100 00%	100 00%

Figure 6-2. Year and Semester of Enrollment: Georgia State Native Group

Year	Frequency	Percent	Cumulative Percent
1970	6	.08%	.08%
1971	19	.24%	.32%
1972	31	.39%	.71%
1973	53	.68%	1.39%
1974	76	.97%	2.36%
1975	86	1.10%	3.45%
1976	112	1.43%	4.88%
1977	178	2.27%	7.15%
1978	177	2.25%	9.40%
1979	196	2.50%	11.90%
1980	326	4.15%	16.05%
1981	464	5.91%	21.96%
1982	634	8.08%	30.04%
1983	891	11.35%	41.39%
1984	1071	13.64%	55.03%
1985	1206	15.36%	70.39%
1986	1088	13.86%	84.25%
1987	898	11.44%	95.69%
1988	338	4.31%	100.00%
Total	7,850	100.00%	100.00%

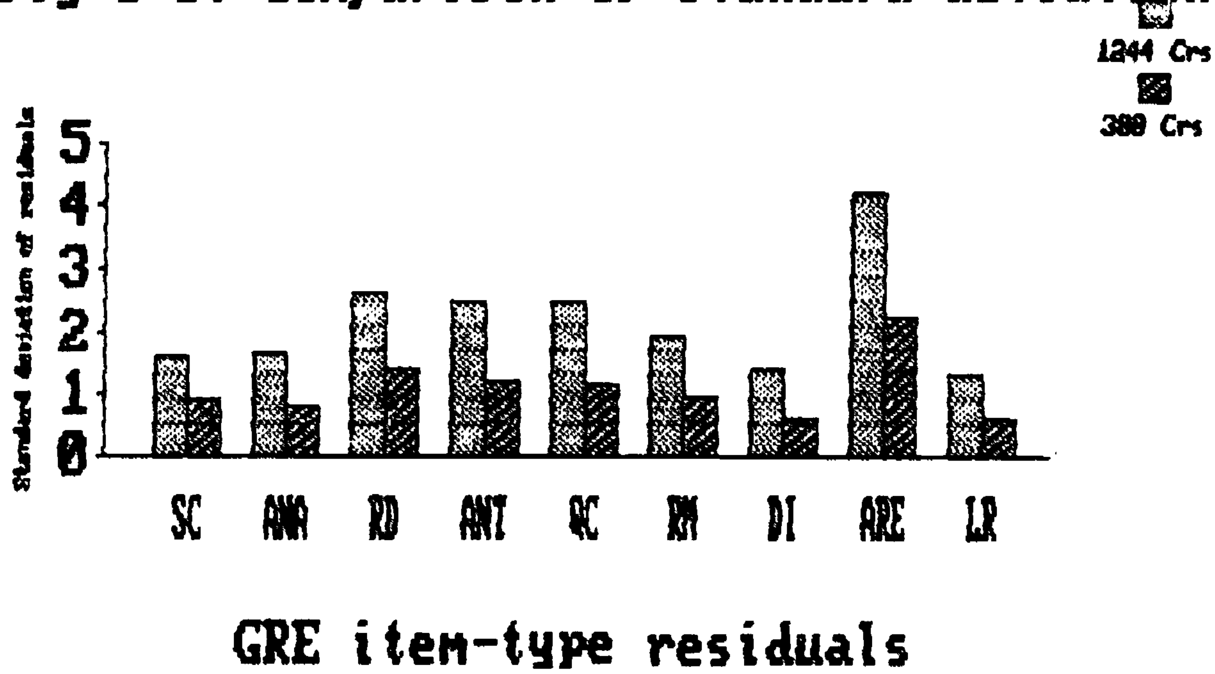
Figure 6-3. The distribution of GRE item-type residuals for 1,244 unduplicated courses in Georgia State Native College Group

GRE Item-types	Number of Items	Max Value	Min Value	Score Range	Residual Means	Std Error of Mean	Std Deviation
Analogy	18	6.77	-5.01	11.78	.0452	.0448	1.5811
Sentence Completion	14	6.02	-5.94	11.96	.2218	.0467	1.6456
Reading Comprehension	22	6.04	-8.93	14.98	.0999	.0750	2.6456
Antonyms	22	7.47	-7.37	14.84	.2747	.0695	2.4529
Quantitative Comparison	30	6.13	-12.82	18.95	.1978	.0700	2.4678
Regular Mathematics	20	7.40	-5.77	13.17	-.2239	.0550	1.9404
Data Interpretation	10	4.46	-3.96	8.42	.0660	.0392	1.3811
Analytical Reasoning	38	10.22	-18.93	-10.69	-.4648	.1196	4.2175
Logical Reasoning	12	4.94	-3.39	8.33	.0438	.0369	1.3001
GRE Item-types:							
Minimum	10	4.46	-18.93	-10.69	-.4648	.0369	1.3001
Maximum	38	10.22	-3.39	18.95	.2747	.1196	4.2175
Mean	21	6.61	-8.01	10.19	.0269	.0640	2.2564
Total	186				.2154		

Figure 6-4. The distribution of GRE item-type residuals for 300 Georgia State Native courses used in the Qualitative Cluster Analytic Procedure (Procedure 1).

GRE Item-types	Number of Items	Max Value	Min Value	Score Range	Residual Means	Std Error of Mean	Std Deviation
Analogy	18	4.07	-2.43	6.50	.0690	.0518	.8968
Sentence Completion	14	5.13	-2.79	7.92	.0559	.0448	.7768
Reading Comprehension	22	3.86	-6.61	10.47	.1521	.0805	1.3937
Antonyms	22	3.83	-5.33	9.16	-.0549	.0677	1.1732
Quantitative Comparison	30	3.50	-5.72	9.22	-.0170	.0650	1.1261
Regular Mathematics	20	2.57	-4.47	7.04	-.0090	.0542	.9393
Data Interpretation	10	1.86	-1.90	3.76	.0420	.0329	.5694
Analytical Reasoning	38	9.56	-10.31	19.87	.1414	.1291	2.2364
Logical Reasoning	12	1.82	-1.70	3.52	.0538	.0337	.5837
GRE Item-types:							
Minimum	10	1.82	-10.31	3.52	-.0549	.0329	.5694
Maximum	38	9.56	-1.70	19.87	.1521	.1291	2.2364
Mean	21	4.02	-4.58	8.61	.0455	.0635	1.0998
Total	186				.3643		

Fig 6-5. Comparison of standard deviation



For each course taken by the Georgia State Native Group, the mean of GRE item-type residuals for students enrolled in the course was calculated. As means for GRE residuals for all courses and for courses enrolling 5 or more students were calculated, certain trends emerged. Examination of Figures 6-3 to 6-5 show that as student data were aggregated according to courses enrolling 5 or more students, the standard deviation of these means was considerably smaller than those for all courses. This trend suggested that there are relationships between the coursework taken and the student score gains on the tests.

Cluster Analysis of Georgia State Native Group

Creating the raw data matrix and the resemblance matrix

Using the mean residuals of the Georgia State Native Group and the 300 courses found on 5 or more of the Georgia State Native student transcripts, a raw data matrix was created. The data matrix consisted of 300 columns and 9 rows (300 x 9). The rows represented the criterion variables: the 9 GRE item-type residual scores. The columns represented those courses enrolling 5 or more students. Thus, each cell value of the matrix was a mean GRE item-type residual score for those sample group students enrolling in a specific course.

A resemblance matrix was created next to describe how closely each course resembles the other 299 courses according to the criterion variables: the student residuals. To calculate the resemblance matrix, the correlation coefficient was selected as a similarity measure. The correlation coefficient was the Pearson product-moment correlation coefficient. Thus, this coefficient assesses a pattern similarity of any two courses explained in terms of the 9 GRE item-type residuals

The resemblance matrix produced in this step consisted of 300 rows and 300 columns (300 x 300), in which each cell value theoretically ranged from -1.00 to 1.00. The calculation of the resemblance matrix was done using the SPSSx PROXIMITY program. The program provides 37 different proximity measures. Ten of them are for quantitative data and the remainder are for binary or qualitative data. This program can directly produce distance, dissimilarity, or similarity matrices as text files for a small to moderate number of cases and variables, which can be directly used for other SPSSx procedures or for other statistical programs. BMDP P1M can also be used to calculate the correlation resemblance matrix and save it as a text file.

Selection of the clustering method

The method selected for this quantitative analysis was the average linkage method (UPGMA). The appropriateness of the Average Linkage Method was discussed in the Task #4 Report of this project (Ratcliff, 1989). Contrary to reports by Romesburg (1984), UPGMA is available in SPSSx, SAS, and BMDP. All the three statistical packages provide UPGMA as an option of the cluster program and use an identical method to compute distances between clusters. In this analysis, the UPGMA method in the cluster program of SPSSx was employed for the sake of convenience. The original dendrogram of the Georgia State Native Group courses produced by SPSS-X is presented in Figure 6-6.

Courses were classified into 13 coursework patterns according to a hierarchical cluster structure. In fact, the choice to present the data in 13 clusters is arbitrary. Any number of clusters can be identified depending on the hierarchical cluster structure produced; this structure remains constant regardless of the number of clusters used to form coursework patterns. A procedure for selecting the optimum number of clusters and for validating the resulting patterns will be described in greater detail in a subsequent section on the discriminant analysis of the coursework patterns in the Georgia State Native Group.

Using a 13 cluster solution to the quantitative cluster analysis, the largest number of courses are found in Coursework Cluster #1 with 53 courses and Cluster #6 with 50 courses. The smallest clusters are the 13th cluster with 3 courses and the 8th cluster with 4 courses. Overall, the differentiation between clusters is attributable to the number of criterion variables used in the analysis and also to the choice of those variables. The cluster analysis and subsequent discriminant analysis suggested that student residuals on GRE item-types are strong, reliable and robust measures in differentiating student general learned abilities.

The hierarchical cluster structure is presented in the dendrogram summary of Figure 6-7. For concise visual presentation, the complex sub-structures of each of the clusters were omitted from the dendrogram. The dendrogram displays the clusters being combined and the distances between the clusters at each successive step, suggesting that the 13-cluster solution examined is appropriate and interpretable. Cluster analyses using smaller and larger numbers of cluster groupings provided comparably high levels of correct classification, as determined by subsequent discriminant analyses. However, as the resemblance index increases (Euclidean distance between courses), more distant courses are joined into larger and larger clusters. A 5-cluster solution, for example, provides a high degree of aggregation which may prove to have a high degree of predictive validity but a low level of utility in differentiating coursework by item-type.

Figure 6-6. SPSS-X Dendrogram.

DENDROGRAM USING AVERAGE LINKAGE (BETWEEN GROUPS)

RESCALED DISTANCE CLUSTER COMBINE

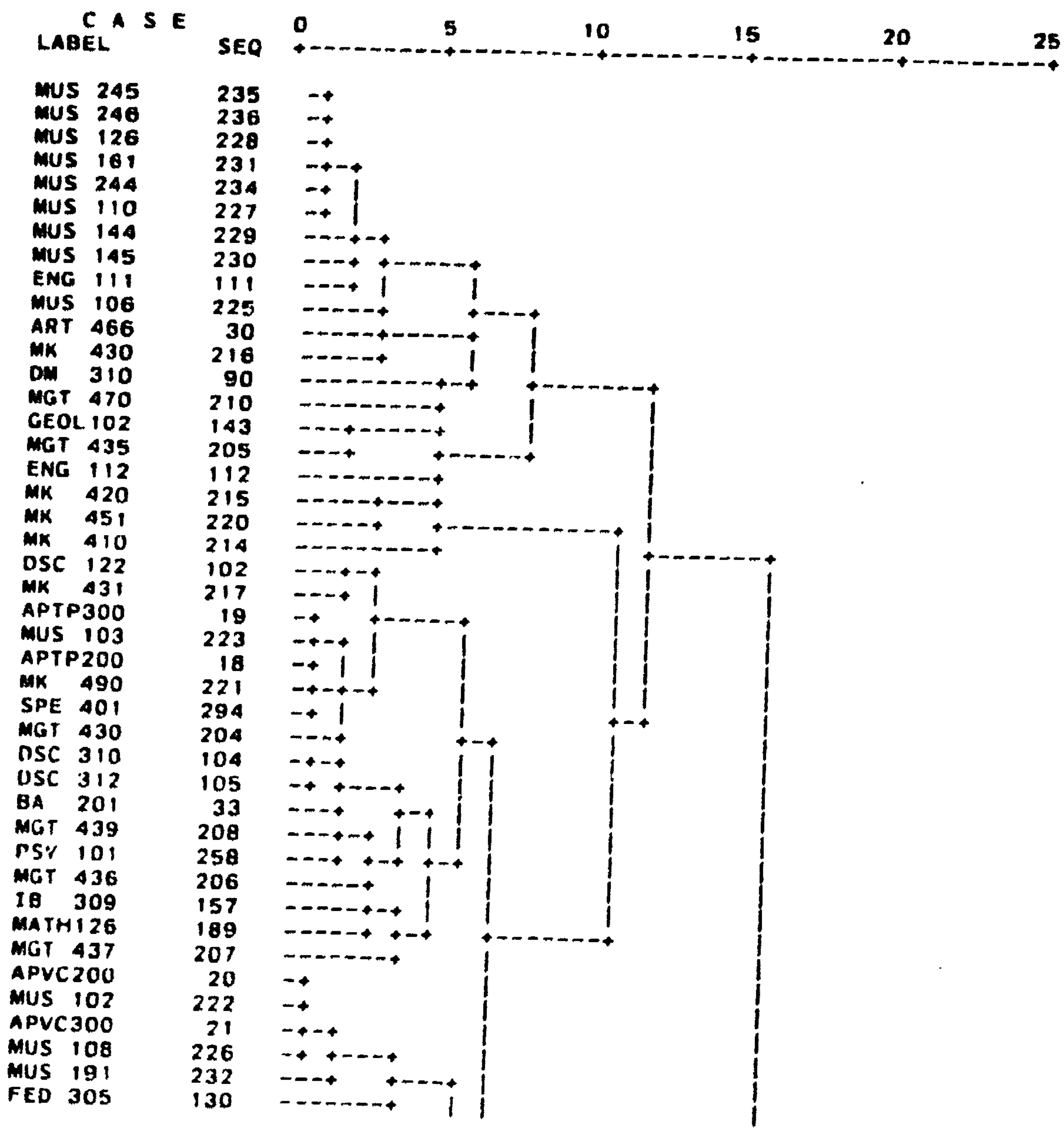


Figure 6-6. SPSS-X Dendrogram.

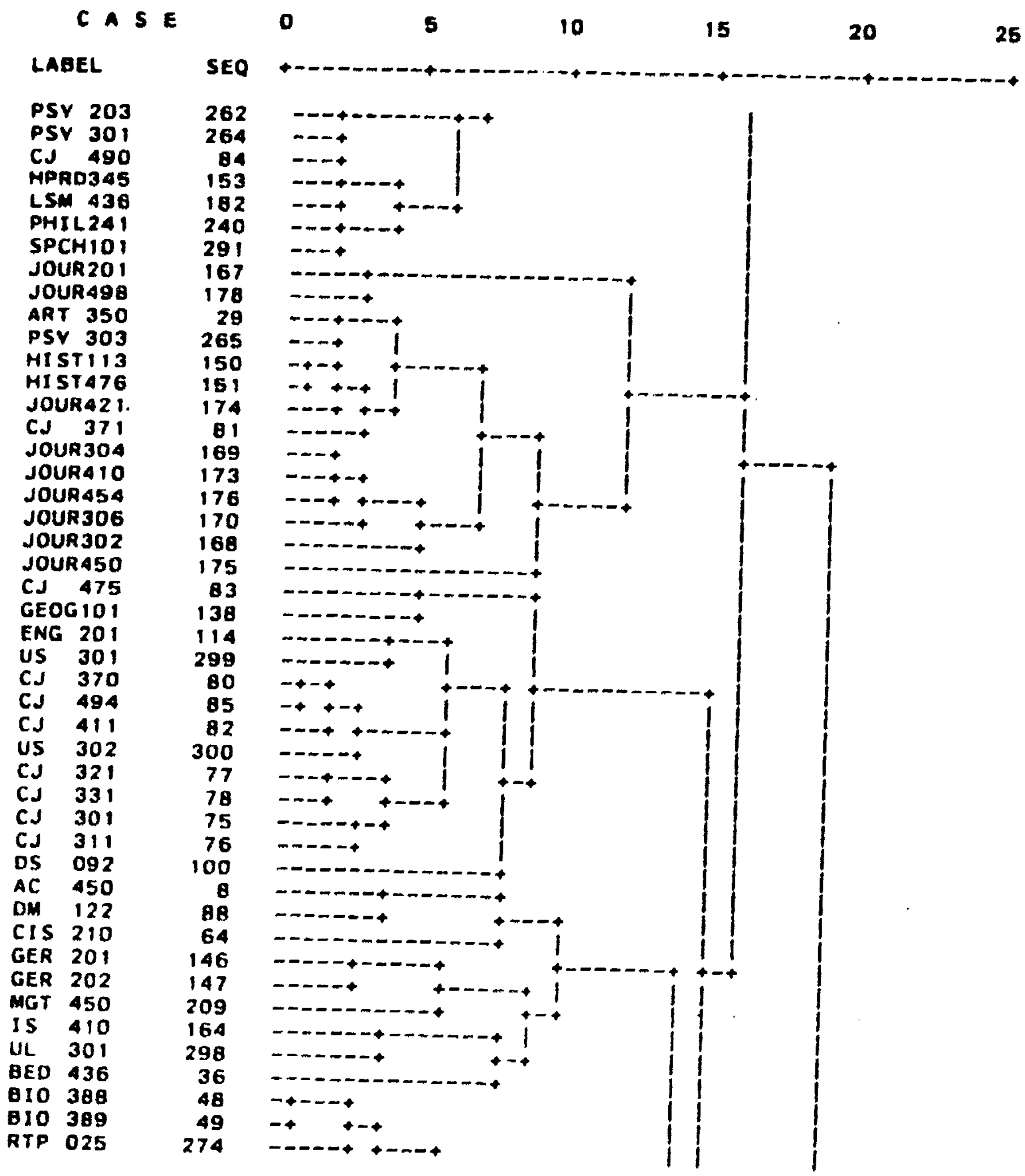


Figure 6-6. SPSS-X Dendrogram.

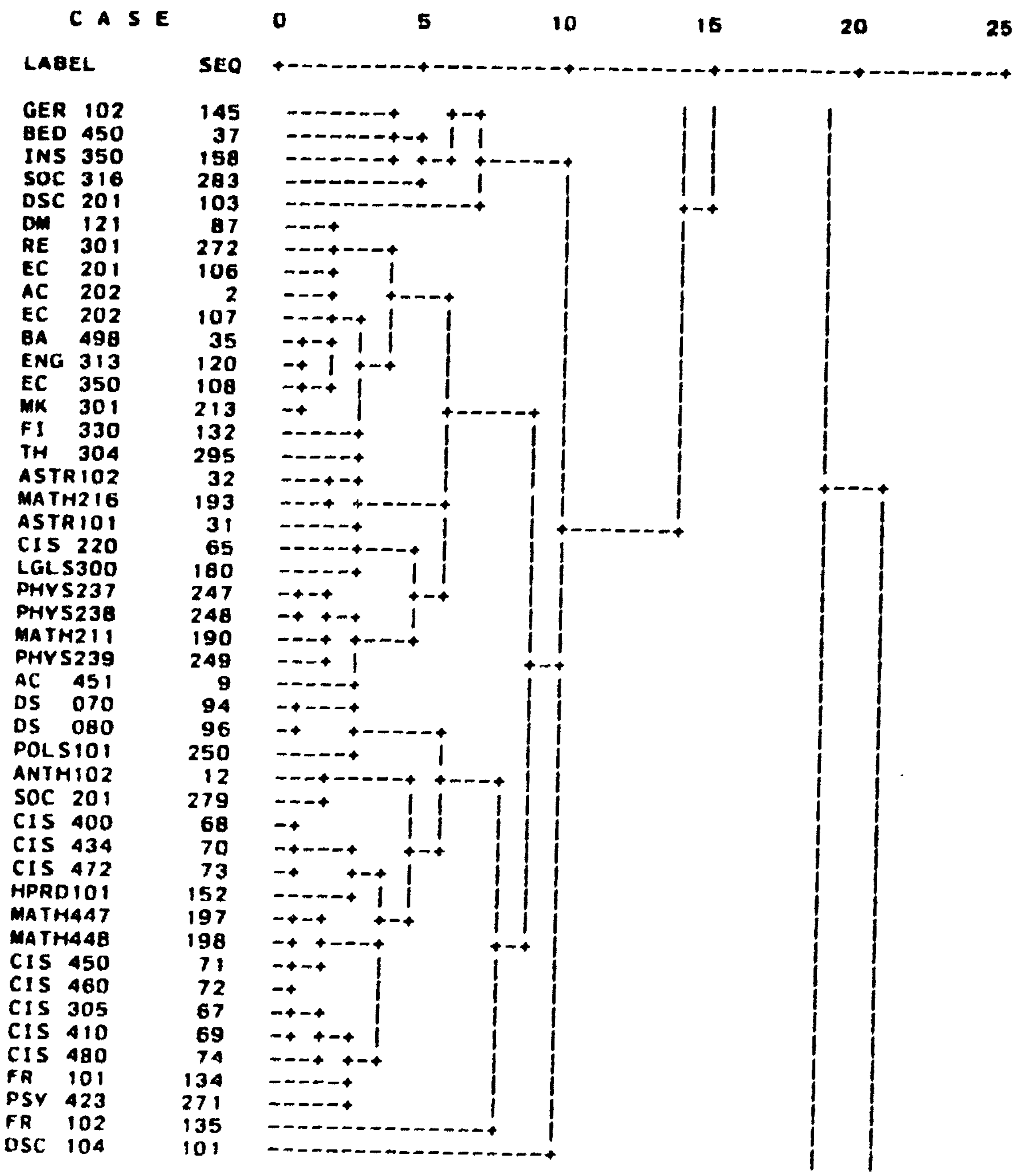


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Figure 6-6. SPSS-X Dendrogram.

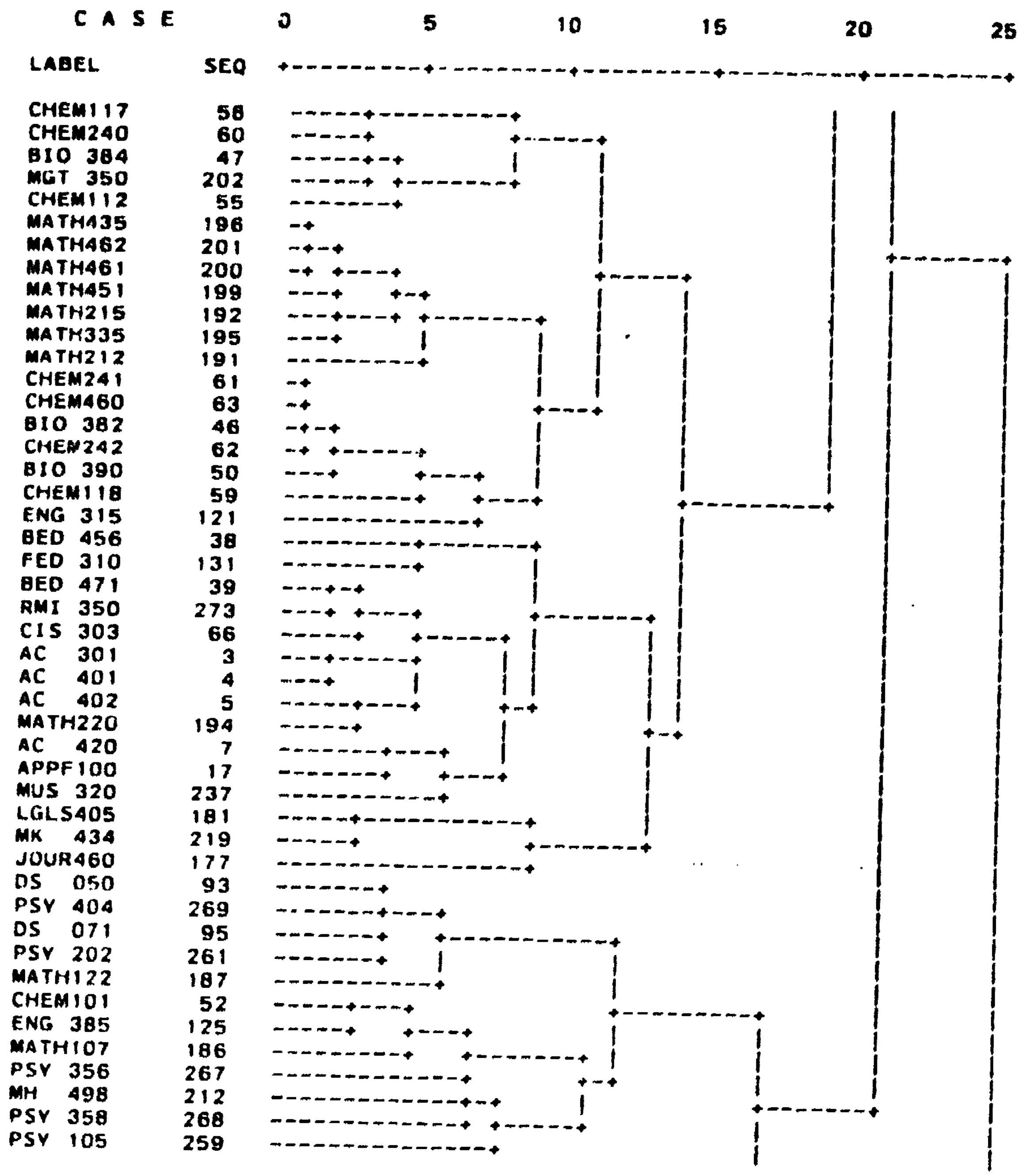

Figure 6-6. SPSS-X Dendrogram.

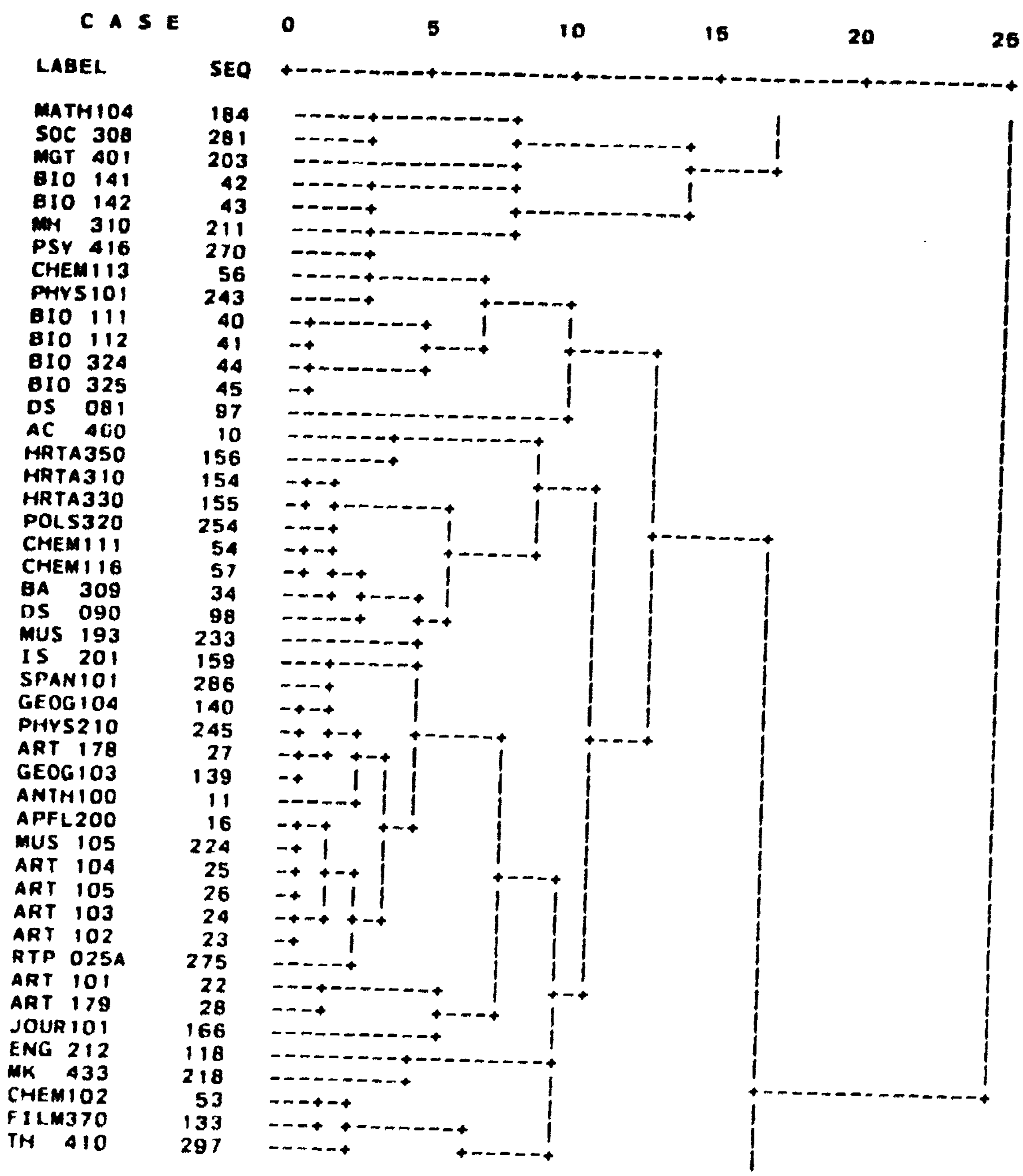

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Figure 6-6. SPSS-X Dendrogram.

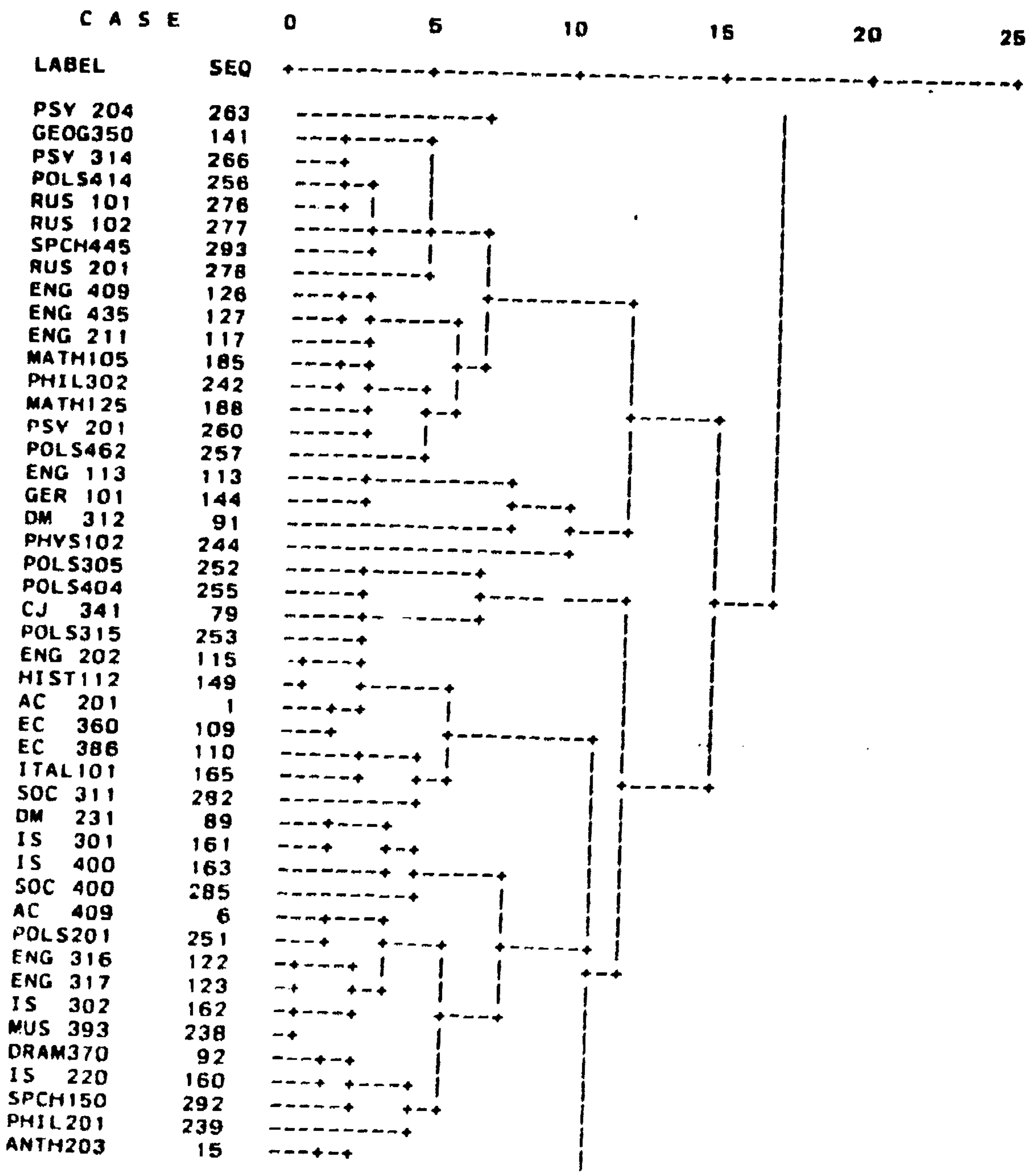

Figure 6-6. SPSS-X Dendrogram.

```
  C A S E      0         5         10        15        20        25
LABEL     SEQ  +---------+---------+---------+---------+---------+

HIST111   148   ---+ |               |
ANTH201    13   -+   +---+           |
ANTH202    14   -+-+ |   |           |
ENG 208   116   -+ +-+   |           |
SPAN303   290   ---+     +---+       |
BL   301   51   ---+     |   |       |
CM   105   86   ---+---+ |   |       |
PHYS230   246   ---+   | |   |       |
SPAN201   288   -+-+   +-+   |       |
SPAN202   289   -+ +-+ |     +-----+ |
SPAN102   287   ---+ +-+     |     | |
TH   370  296   -----+       |     | |
GEOL101   142   ---+-+       |     | |
JOUR308   171   ---+ +---+   |     | |
JOUR309   172   -----+   +-+ |     | |
PHIL301   241   -----+   | +-+     +-+
MATH102   183   ---------+ |       |
LAT  101  179   -----------+       |
EXC  401  128   -+-----+           |
FED  210  129   -+     +-+         |
DS   091   93   -------+ +-------+ |
SOC  202  280   ---------+       +-+
ENG  280  119   -----+---+       |
ENG  370  124   -----+   +-------+
FR   201  136   -+-----+ |
FR   202  137   -+     +-+
SOC  317  284   -------+
```

Figure 6-7. Dendrogram of hierarchical cluster structure--Georgia State Natives

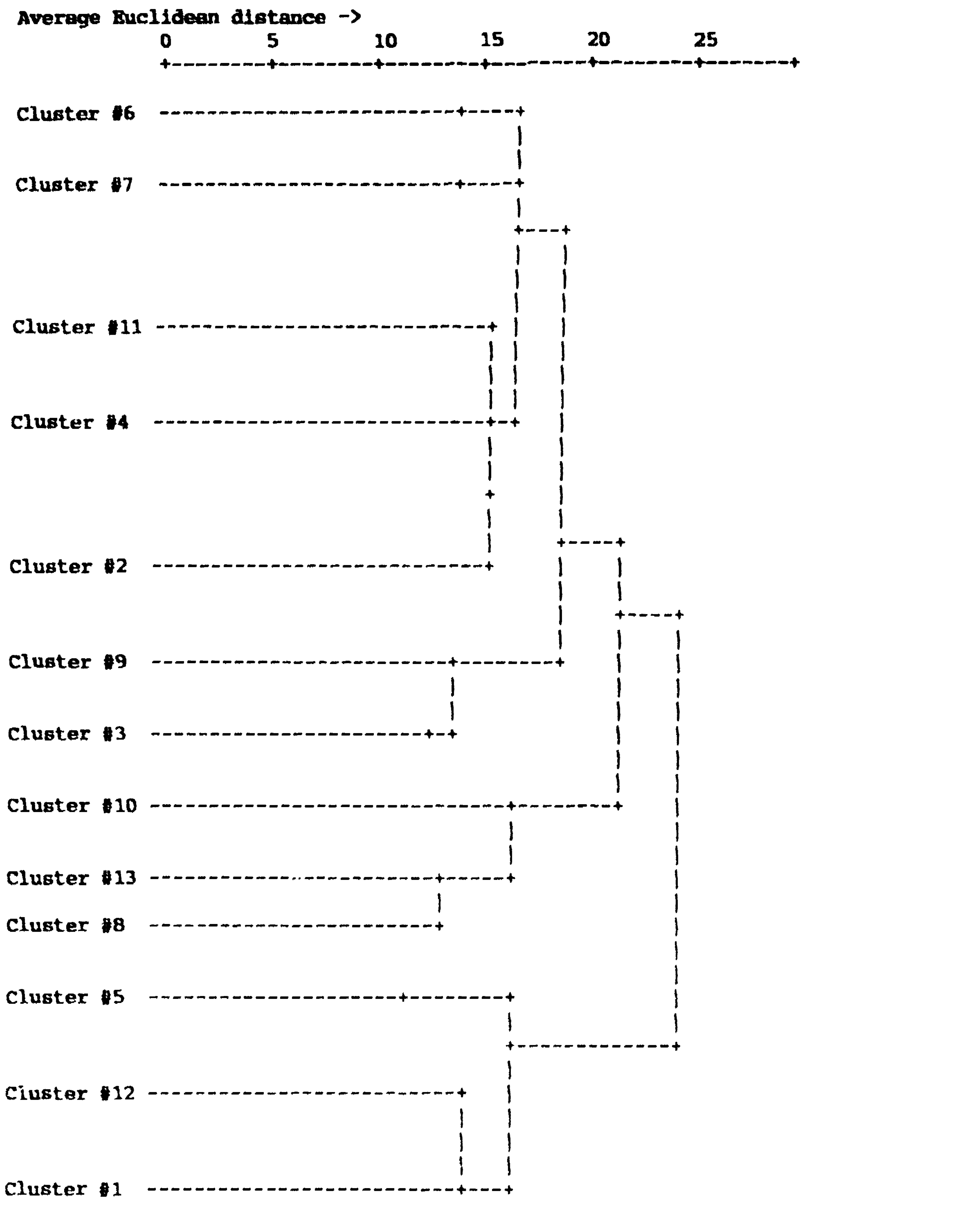

Figure 6-8a. Courses within coursework clusters (13-cluster solution): Natives

Cluster #1 n = 53	Cluster #1 Continued	Cluster #2 n = 49	Cluster #2 Continued	Cluster #3 n = 14
AC 201	SOC 202	AC 202	PSY 423	AC 301
AC 409	SOC 311	AC 451 *	RE 301	AC 401
ANTH 201	SOC 317	ANTH 102	RTP 25	AC 402
ANTH 202	SOC 400 *	ASTR 101	SOC 201	AC 420
ANTH 203	SPAN 102	ASTR 102	SOC 316	APPF 100 *
BL 301	SPAN 201	BA 498	TH 304	BED 456
CJ 341	SPAN 202	BED 450		BED 471
CM 105	SPAN 303	BIO 388 *		CIS 303
DM 231	SPCH 150 *	BIO 389 *		JOUR 460 *
DRAM 370	TH 370	CIS 220		LGLS 405
DS 91		CIS 305		MATH 220
EC 360		CIS 400		MK 434
EC 386		CIS 410		MUS 320
ENG 202		CIS 434		RMI 350
ENG 208		CIS 450		
ENG 280		CIS 460		
ENG 316		CIS 472		
ENG 317		CIS 480		
ENG 370		DM 121		
EXC 401		DS 70		
FED 210		DS 80		
FR 201		DSC 104		
FR 202		DSC 201		
GEOL 101		EC 201		
HIST 111		EC 202		
HIST 112		EC 350		
IS 220		ENG 313		
IS 301 *		FI 330		
IS 302		FR 101		
IS 400		FR 102		
ITAL 101		GER 102		
JOUR 308		HPRD 101		
JOUR 309		INS 350		
LAT 101		LGLS 300		
MATH 102		MATH 211		
MUS 393		MATH 216		
PHIL 201 *		MATH 447		
PHIL 301		MATH 448		
PHYS 230		MK 301		
POLS 201		PHYS 237		
POLS 305 *		PHYS 238		
POLS 315		PHYS 239 *		
POLS 404		POLS 101		

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-8b. Courses within coursework clusters (13-cluster solution): Natives

Cluster #4		Cluster #5		Cluster #6		Cluster #6		Cluster #7	
n = 9		n = 38		n = 50		Continued		n = 14	
AC	450	AC	460 *	APTP	200	MUS	244	ART	350
BED	436 *	ANTH	100	APTP	300	MUS	245	CJ	371
CIS	210 *	APFL	200	APVC	200	MUS	246	HIST	113 *
DM	122 *	ART	101	APVC	300	PHIL	241 *	HIST	476
GER	201	ART	102	ART	466	PSY	101	JOUR	201
GER	202	ART	103	BA	201	PSY	203	JOUR	302
IS	410	ART	104	CJ	490 *	PSY	301 *	JOUR	304
MGT	450	ART	105	DM	310	SPCH	101	JOUR	306
UL	301	ART	178	DSC	122 *	SPE	401	JOUR	410
		ART	179 *	DSC	310			JOUR	421
		BA	309	DSC	312			JOUR	450 *
		BIO	111	ENG	111 *			JOUR	454
		BIO	112	ENG	112 *			JOUR	498
		BIO	324	FED	305			PSY	303
		BIO	325	GEOL	102 *				
		CHEM	102	HPRD	345				
		CHEM	111	IB	309				
		CHEM	113	LSM	436				
		CHEM	116	MATH	126 *				
		DS	81	MGT	430				
		DS	90 *	MGT	435 *				
		ENG	212 *	MGT	436				
		FILM	370	MGT	437 *				
		GEOG	103	MGT	439				
		GEOG	104	MGT	470				
		HRTA	310	MK	410 *				
		HRTA	330	MK	420				
		HRTA	350 *	MK	430				
		IS	201	MK	431				
		JOUR	101 *	MK	451 *				
		MK	433	MK	490				
		MUS	105	MUS	102				
		MUS	193	MUS	103				
		PHYS	210	MUS	106				
		PSY	204 *	MUS	108				
		RTP	25A	MUS	110				
		SPAN	101	MUS	126				
		TH	410 *	MUS	144				
				MUS	145				
				MUS	161				
				MUS	191				

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-8c. Courses within coursework clusters (13-cluster solution): Natives

Cluster #8 (n = 4)

BIO	141	*
BIO	142	*
PSY	416	
MH	310	*

Cluster #9 (n = 19)

BIO	325	
BIO	384	
BIO	390	
CHEM	112	
CHEM	117	*
CHEM	118	
CHEM	240	
CHEM	241	
CHEM	242	
CHEM	460	
ENG	315	*
MATH	212	*
MATH	215	
MATH	335	
MATH	435	
MATH	451	
MATH	461	
MATH	462	
MGT	350	*

Cluster #10 (n = 12)

CHEM	101	
DS	50	*
DS	71	*
ENG	385	
MATH	107	*
MATH	122	
MH	498	
PSY	105	
PSY	202	
PSY	356	
PSY	358	
PSY	404	

Cluster #11 (n = 13)

CJ	301	
CJ	311	
CJ	321	
CJ	331	
CJ	370	
CJ	411	
CJ	475	
CJ	494	
DS	92	
ENG	201	*
GEOG	101	*
US	301	
US	302	

Cluster #12 (n = 19)

DM	312	*
ENG	113	*
ENG	211	
ENG	409	
ENG	435	
GEOG	350	
GER	101	*
MATH	105	
MATH	125	
PHIL	302	*
PHYS	102	*
POLS	414	
POLS	462	
PSY	201	
PSY	314	*
RUS	101	
RUS	102	
RUS	201	
SPCH	445	

Cluster #13 (n = 3)

MATH	104	*
MGT	401	*
SOC	308	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Observations about the Clusters

A careful examination of courses within each cluster seems to indicate that some courses coming from the same department appear in the same cluster, such as the English courses (ENG) in Cluster #1, the Computer Information System (CIS) courses in Cluster #2, and the Journalism (JOURN) courses in Cluster #7. Similarly, there are apparent sequences of courses, such as Anthropology 201, 202, and 203 sequence in Cluster #1. Also, a set of courses coming from various related disciplines may form a homogeneous cluster on the basis of a set of given attributes or criteria. The homogenity of disciplines is particularly apparent in Cluster #1. Nevertheless, the humanities and social sciences seem to predominate this group.

At this point in the analysis, it is difficult to describe which dimensions of student general learned ability each cluster represents. However, it seems to be clear that one pattern of course enrollment may contribute to student general learned ability in a way significantly different from the other coursework patterns. Supporting this is a more detailed examination of subset courses of each clusters. In many cases, those courses offered at the same level tend to be combined into pairs together. But, those pairs are agglomerated with other courses offered at the higher level again according to the hierarchical structure of clusters. This may suggest that student gains in general learned abilities may be obtained through a sequential enrollment pattern during the college years, not at a single stage of the sequence (such as the freshman year experience).

Discriminant analysis of coursework patterns

In examining the dendrogram of the Georgia State Native Group, a logical question arises as to which number of clusters or pattern groupings provides the best explanation of the relationship between student item-type score gains and coursework patterns. Separate discriminant analyses of different numbers of cluster groupings were be performed in order to determine the number of groupings that optimizes the proportion of courses correctly classified. Four different cluster solutions provided comparably high levels of correct classification:

8 cluster solution : 81.67% of courses correctly classified
11 cluster solution : 83.00% of courses correctly classified
13 cluster solution : 81.33% of courses correctly classified
15 cluster solution : 80.33% of courses correctly classified

While these cluster solutions produced comparable classification results, the different grouping evidenced differing effectiveness in identifying relationships between mean item-type residual scores and coursework patterns. The 13-cluster solution was used in this report.

The discriminant analysis was conducted using the DISCRIMINANT program in SPSSx in the following manner. Using the course item-type attributes as independent variables and the cluster group membership as the dependent variables, discriminant functions were applied to the data. The discriminant functions and the courses item-type mean residual scores were used to see how correctly the discriminant function identifies each cluster group. The resulting percentage of correct predictions serves as a secondary validation of the cluster solution (Bradfield and Orloci, 1975; Green and Vascotto, 1978; Romesburg, 1984).

Figure 6-9. Discriminant analysis of the 13-cluster solution for Georgia State Native Sample

Actual Cluster	No. of Cases	Gr 1	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12	Gr 13
		Predicted Group Membership												
Group 1	53	48	3	0	0	0	0	0	0	0	0	1	1	0
		90.6%	5.7%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	1.9%	1.9%	.0%
Group 2	49	0	45	1	0	0	0	0	0	3	0	0	0	0
		.0%	91.8%	2.0%	.0%	.0%	.0%	.0%	.0%	6.1%	.0%	.0%	.0%	.0%
Group 3	15	0	0	12	0	1	0	0	0	0	0	2	0	0
		.0%	.0%	80.0%	.0%	6.7%	.0%	.0%	.0%	.0%	.0%	13.3%	.0%	.0%
Group 4	9	1	2	0	6	0	0	0	0	0	0	0	0	0
		11.1%	22.2%	.0%	66.7%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
Group 5	40	2	2	0	1	31	1	0	1	0	1	1	0	0
		5.0%	5.0%	.0%	2.5%	77.5%	2.5%	.0%	2.5%	.0%	2.5%	2.5%	.0%	.0%
Group 6	50	2	7	2	0	0	38	0	0	0	0	1	0	0
		4.0%	14.0%	4.0%	.0%	.0%	76.0%	.0%	.0%	.0%	.0%	2.0%	.0%	.0%
Group 7	14	0	1	0	0	0	0	13	0	0	0	0	0	0
		.0%	7.1%	.0%	.0%	.0%	.0%	92.9%	.0%	.0%	.0%	.0%	.0%	.0%
Group 8	4	2	0	0	0	0	0	0	2	0	0	0	0	0
		50.0%	.0%	.0%	.0%	.0%	.0%	.0%	50.0%	.0%	.0%	.0%	.0%	.0%
Group 9	19	0	3	0	0	1	0	0	0	15	0	0	0	0
		.0%	15.8%	.0%	.0%	5.3%	.0%	.0%	.0%	78.9%	.0%	.0%	.0%	.0%
Group 10	12	0	3	0	0	0	0	0	0	0	9	0	0	0
		.0%	25.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	75.0%	.0%	.0%	.0%
Group 11	13	0	2	0	0	0	0	0	0	0	0	11	0	0
		.0%	15.4%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	84.6%	.0%	.0%
Group 12	19	1	2	0	0	2	0	0	0	0	1	0	13	0
		5.3%	10.5%	.0%	.0%	10.5%	.0%	.0%	.0%	.0%	5.3%	.0%	68.4%	.0%
Group 13	3	0	2	0	0	0	0	0	0	0	0	0	0	1
		.0%	66.7%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	33.3%

Percent of "Grouped" Clusters correctly classified: 81.33%

Correlations of item-types and discriminant functions

The discriminant analysis of Georgia State Native Group provided secondary validation that 81.33% of the classification of courses was correctly predicted by the cluster analysis (See Figure 6-9). The discriminant analysis is a secondary validation, since it is based on the same sample of transcripts and test scores.

Stated simply, approximately 8 of 10 courses most frequently taken by Georgia State Native students were correctly classified according to their mean residual GRE scores. While the cluster analysis produces coursework patterns according to criteria of general student learning, additional steps are needed (1) to determine which courses were correctly classified and (2) to ascertain which item-type residual scores contributed to any given coursework pattern.

Using the BREAKDOWN procedure in the DISCRIMINANT program of SPSS-X (Norusis, 1985), courses which were incorrectly classified or which may be classified within another coursework pattern are identified. These courses are marked with an "*" in Figure 6-8. When a set of data is taxonomized by multiple and independent criteria, it is reasonable to expect that the first groupings are generally the most homogeneous and the later groupings are the most heterogeneous. Consequently, the highest proportions of misclassifications occurred in Clusters #4, #5, #6, #8, #12 and #13, while Clusters #1 and #2 had relatively few misclassifications.

To compute the contribution of each mean item-type residual score to the discriminant functions, the correlation coefficients between mean residual scores and discriminant functions were examined. Figure 6-10 shows the pooled within-group correlations for the 13-cluster solution of Georgia State Native Group coursework.

Figure 6-10. Pooled within-group correlation between mean item-type residual scores and discriminant functions for Georgia State Native Group.

Mean Residual Item-Type	Func 1	Func 2	Func 3	Func 4	Func 5	Func 6	Func 7	Func 8	Func 9
Analytic Reasoning	**.6134** *	.3644	.0083	.5712	-.1139	.1953	.2710	-.1191	-.1609
Quantitative Comparisons	.0394	-.1567	.4340	.4978	**.6651** *	-.0108	.3045	-.0037	-.0509
Regular Mathematics	.3521	-.1719	.4048	.2269	-.1873	**.6539** *	.2927	-.1688	.2331
Reading Comprehension	-.1966	.5880	**.6441** *	.3851	.0162	.1140	.1968	.0225	-.0012
Antonyms	**-.6240** *	.1827	-.2455	.3286	.3467	.1461	.2833	-.1022	.4205
Sentence Completion	-.1105	.0860	-.2525	.1562	-.3054	.1186	**.6816** *	.0213	-.5656
Analogies	.0781	-.2810	-.0014	.3301	-.4644	-.4333	**.6081** *	-.1268	-.1293
Data Interpretation	.1369	.0964	.0134	-.0494	.1303	.0587	.4153	**.7576** *	.4500
Logical Reasoning	.0316	.1246	.0272	-.3969	.2784	-.1853	**.7409** *	-.4018	.0545

Note. Mean residual item-type correlations ordered by size within function. Mean Item-type residuals with large coefficients are presented in bold, grouped together and are marked with asterisks (*).

Correlations of coursework clusters and discriminant functions

Figure 6-10 summarizes relationships between GRE item-type residuals and discriminant functions:

Function 1 was negatively correlated with Antonyms (r=-.62), and was positively correlated with Analytic Reasoning (r=.61);

Function 2 was positively correlated with Reading Comprehension (r=.59);

Function 3 was positively correlated with Reading Comprehension (r=.64);

Function 4 was positively correlated with Analytic Reasoning (r=.57), and was positively correlated with Quantitative Comparisons (r=.50);

Function 5 was positively correlated with Quantitative Comparisons (r=.67);

Function 6 was positively correlated with Regular Mathematics (r=.65);

Function 7 was positively correlated with Analogies (r=.61), was positively correlated with Sentence Completion (r=.68), and was positively correlated with Logical Reasoning (r=.74);

Function 8 was positively correlated with Data Interpretation (r=.76);

Function 9 was negatively correlated with Sentence Completion (r=-.57).

The pooled within-group correlations established relationships between the discriminant functions and the GRE item-type residuals. Each discriminant function explains a certain proportion of the variation in residual scores.

Discriminant functions with strong explanatory power, "good discriminant functions," have large between-cluster variability and low within-cluster variability (Haggerty, 1975; Norusis, 1985). The eigenvalues of Figure 6-23 present the ratio of between-group to within-group sums of squares of the residuals. Large eigenvalues are associated with the discriminant functions that most contribute to explaining variability in GRE item-type scores.

Wilk's Lambda is the ratio of the within-group sum of squares to the total sum of the squares. It represents the proportion of the total variance in the discriminant function values not explained by differences among cluster groups. Wilk's Lambda serves as a test of the null hypothesis that there is no difference in the mean residuals of a coursework cluster means and the mean residual scores of the coursework in the total sample.

Thus, the eigenvalues and canonical correlations indicate the extent to which each discriminant function contributes to our understanding of the variability in coursework mean residuals. Lambda test the null of the differential coursework hypothesis for each discriminant function.

Figure 6-11. Canonical discriminant functions: Georgia State Native Group

Function	Eigen-Value	Percent of Variance	Cumulative Percent	Canonical Correlation	Wilk's Lambda	Degrees Freedom	Significance
0					.0247	108	.0000
1	1.6618	30.83%	30.83%	.7901	.0657	88	.0000
2	1.3113	24.33%	55.16%	.7532	.1519	70	.0000
3	.8145	15.11%	70.27%	.6700	.2757	54	.0000
4	.7632	14.16%	84.43%	.6579	.4861	40	.0000
5	.5067	9.40%	93.82%	.5799	.7323	28	.0000
6	.1918	3.56%	97.38%	.4012	.8728	18	.0027
7	.0990	1.84%	99.22%	.3001	.9592	10	.2845
8	.0256	.47%	99.69%	.1579	.9837	4	.3151
9	.0166	.31%	100.00%	.1278			

Figure 6-12. Canonical discriminant functions evaluated at group means.

Cluster	Func 1	Func 2	Func 3	Func 4	Func 5	Func 6	Func 7	Func 8	Func 9	Minimum	Maximum	Average
Cluster #1	-1.3579	.9989	.1560	-.8726	.3073	-.3984	-.0452	.4111	-.1456	-1.3579	.9989	-.1052
Cluster #2	1.1563	.8198	.1260	-.0312	-.2500	-.3509	-.3186	-.3162	-.1454	-.3509	1.1563	.0766
Cluster #3	-.1258	-.6376	-1.0305	1.4587	-.5443	.1301	.8223	-1.0257	.1379	-1.0305	1.4587	-.0905
Cluster #4	-.0796	1.0111	-1.3948	.3299	1.1899	-.9433	-.0267	-.6102	.4132	-1.3948	1.1899	-.0123
Cluster #5	-1.6043	-1.4015	.3904	.6182	-.3567	.4197	-.0095	.0475	-.3693	-1.6043	.6182	-.2517
Cluster #6	1.1021	-.9841	-1.0649	-.5749	.0788	.6357	.5798	-.1121	.4763	-.9841	1.1021	.1263
Cluster #7	1.2354	-.4306	-.1244	-.7350	1.6325	-.6735	-1.9183	-.2743	.5885	-1.9183	1.6325	-.0777
Cluster #8	-.5116	-.5367	.6794	-.9594	-.8844	.1355	1.2345	.5577	-.5681	-.9594	1.2345	
Cluster #9	-.2378	1.4266	-.2678	1.5730	-.3743	1.3124	.7080	-.2496	-.3560	-.3743	1.5730	.3927
Cluster #10	.5220	-1.0595	1.3137	-.0040	-1.1973	.0662	-.2229	1.0260	-.4350	-1.1973	1.3137	.0010
Cluster #11	.8406	-.8109	-.2390	1.0540	1.4889	-1.6430	.6189	-.1521	.5261	-1.6430	1.4889	.1871
Cluster #12	-.0625	.8662	2.1906	.0263	-.6340	-.0995	-1.0681	.8303	.0374	-1.0681	2.1906	.2319
Cluster #13	.0818	.1609	.3429	-.9916	-.4671	.8943	.2294	-.4885	-.5079	-.9916	.8943	-.0829
Minimum	-1.6043	-1.4015	-1.3948	-.9916	-1.1973	-1.6430	-1.9183	-1.0257	-.5681			
Maximum	1.2354	1.4266	2.1906	1.5730	1.6325	1.3124	1.2345	1.0260	.5885			
Average	.0731	-.0444	.1598	.0686	-.0008	-.0396	.0449	-.0274	-.0268			

Interpreting the coursework clusters for the 13-cluster solution

Figure 6-12 shows the coursework cluster means (group centroids) for each discriminant function. Clusters with positive or negative means greater than 1.0 were selected for further analysis.

Coursework clusters with positive or negative means greater than 1.0 were selected for further analysis. Coursework Cluster #1 had a high negative group mean on Function 1 and a high positive group mean on Function 2. Function 1 was positively correlated to Analytic Reasoning (r=.61) and was negatively correlated to Antonyms (r=-.62). Function 2 was positively correlated to Reading Comprehension (r=.59). Students enrolling in this coursework improved in Antonyms and Reading Comprehension but declined in their Analytic Reasoning abilities.

Cluster #2 had a high positive group mean on Function 1. Function 1 was positively correlated to Analytic Reasoning (r=.61) and was negatively correlated to Antonyms (r=-.62). Students enrolling in this cluster gained in Analytic Reasoning but declined in Antonyms.

Cluster #3 evidenced a high positive group mean on Function 4 and high negative group mean on Function 3. Function 4 was positively correlated to Analytic Reasoning (r=.57) and Quantitative Comparisons (r=.50). Function 3 was positively correlated to Reading Comprehension (r=.64). Students taking Cluster #3 coursework improved in Analytical Reasoning and Quantitative Comparisons but declined in Reading Comprehension.

Cluster #4 had high positive group means on Functions 2 and 5, and a high negative group mean on Function 3. Function 5 was positively correlated to Quantitative Comparisons (r=.67). Students enrolling in this cluster showed gains in Quantitative Comparisons. The results for Reading Comprehension were inconclusive.

Cluster #5 had high negative group means on Functions 1 and 2. Students enrolled in this coursework gained in Antonyms but declined in Analytic Reasoning and Reading Comprehension.

Cluster #6 encompassed high negative group means on Functions 2 and 3, and a high positive group mean on Function 1. Students signed up for this coursework pattern declined in Antonyms and Reading Comprehension but gained in Analytic Reasoning.

Cluster #7 had high positive group means on Functions 1 and 5. Students taking this coursework pattern gained in Analytic Reasoning and Quantitative Comparisons and declined in Antonyms.

Cluster #8 consisted of three courses. Two courses were misclassified. Therefore, no further analysis was conducted with this cluster.

Cluster #9 had high positive group means on Functions 2 and 4. Students enrolled in these courses improved in Reading Comprehension, Analytic Reasoning, and Quantitative Comparisons.

Cluster #10 had high negative group means on Functions 2 and 5, and a high positive group mean on Function 3. Students enrolling in these clusters showed declines in Quantitative Comparisons. The results for Reading Comprehension were inconclusive.

Cluster #11 encompassed high positive group means on Functions 4 and 5. Students registering in this coursework gained in Quantitative Comparisons and Analytic Reasoning.

Cluster #12 had a high positive group mean on Function 3. Students taking courses in this cluster improved in Reading Comprehension.

Cluster #13 consisted of three courses. Two courses were misclassified. Therefore, no further analysis was conducted with this cluster.

Figures 6-13a--6-13m portray the coursework clusters and the mean residual item-type with which they were found to be associated. It should be cautioned that the association was established at the cluster level. No direct causal link is intimated between student enrollment in any one given course and scores on the GRE. Furthermore, at this point, one cannot say why students who enrolled in these courses had higher score gains. The cluster serves to hypothesize relationships between coursework patterns and the general learned abilities measures by the item-types of the GRE. One can say that students who enrolled in specific patterns of coursework tended to evidence stronger gains on specific item-types within the GRE, while others who enrolled in different coursework patterns did not tend to show such gains. This evidence affirms the hypothesis that student gains in general learned abilities are associated, positively and negatively, with the coursework in which they enrolled. Further analysis is required to determine the nature of these associations.

Figure 6-13a. Cluster 1: High positive mean residuals on Antonyms (ANT) and Reading Comprehension (RD); high negative mean residuals c Analytic Reasoning (ARE).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
1	AC	201	Principles of Accounting I	
1	AC	409	Intermediate Accounting I	
1	ANTH	201	Introduction to Physical Anthropology	
1	ANTH	202	Introduction to Cultural Anthropology	
1	ANTH	203	Introduction to Archaeology	
1	BL	301	Business Law (first course)	
1	CJ	341	Criminology	
1	CM	105	Structure of Music Industry	
1	DM	231	Decision Mathematics III	
1	DRAM	370	History of the Motion Picture	
1	DS	91	Developmental Mathematics II	
1	EC	360	Economics of Urban Problems	
1	EC	386	Dynamics of Labor Problems	
1	ENG	202	European Literature II	
1	ENG	208	The Short Story	
1	ENG	280	Major American Writers 19th/20th Century	
1	ENG	316	Narrative Technique/Creative Writing II	
1	ENG	317	Poetry Techniques/Creative Writing III	
1	ENG	370	Modern British Literature	
1	EXC	401	Exceptional Children/Youth	
1	FED	210	Problems of Urban Education	
1	FR	201	Intermediate French	
1	FR	202	Intermediate French	
1	GEOL	101	Physical Geology	
1	HIST	111	World Civilization Before 1500	
1	HIST	112	World Civilization Since 1500	
1	IS	220	Principles of Computer Programming	
1	IS	301	Introduction to Data Processing	*
1	IS	302	Problem Analysis: FORTRAN Programming Language	
1	IS	400	Principles of Computer Programming	
1	ITAL	101	Elementary Italian	
1	JOUR	308	News Writing and Reporting	
1	JOUR	309	Advanced News Writing and Reporting	
1	LAT	101	Elementary Latin	
1	MATH	102	Basic Algebra	
1	MUS	393	Introduction to Music	
1	PHIL	201	Introduction to Philosophy	
1	PHIL	301	History of Western Philosophy I/400BC-1300AD	
1	PHYS	230	Physics of Music and Speech	
1	POLS	201	Introduction to Political Science	
1	POLS	305	Issues in American Public Policy	
1	POLS	315	Political Parties	
1	POLS	404	American Legislative Process	
1	SOC	202	Contemporary Social Problems	
1	SOC	311	Racial and Cultural Minorities	
1	SOC	317	Sex, Dating, and Interpersonal Relations	
1	SOC	400	Urban Sociology	*
1	SPAN	102	Elementary Spanish	

1	SPAN	201	Intermediate Spanish	
1	SPAN	202	Intermediate Spanish	
1	SPAN	303	Advanced Grammar	
1	SPCH	150	Public Speaking	*
1	TH	370	History of the Motion Picture	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

15?

Figure 6-13b. Cluster 2: High positive mean residuals on Analytic Reasoning (ARE); high negative mean residuals on Antonyms (ANT).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATION
2	AC	202	Principles of Accounting II	
2	AC	451	Federal Income Taxation of Individuals	*
2	ANTH	102	Introduction to Cultural Anthropology	
2	ASTR	101	Descriptive Astronomy	
2	ASTR	102	Descriptive Astronomy	
2	BA	498	Strategic Management/Policy	
2	BED	450	Office Machines I/Business Machines I	
2	BIO	388	Microbiology	*
2	BIO	389	Microbiology Lab	*
2	CIS	220	Principles of Computer Programming I	
2	CIS	305	Assembly Language-Programming for Business Applications	
2	CIS	400	Principles of Computer Programming II	
2	CIS	410	Introduction to Data Structures & Algorthimic Process	
2	CIS	434	Data Management in Business	
2	CIS	450	Systems Analysis and Design	
2	CIS	460	Computer Software: Structure & Organization	
2	CIS	472	Introduction to Database Systems	
2	CIS	480	Computer Hardware	
2	DM	121	Decision Mathematics I	
2	DS	70	Developmental Reading I	
2	DS	80	Developmental English I	
2	DSC	104	College Algebra	
2	DSC	201	Introduction to Management Information Systems	
2	EC	201	Principles of Macroeconomics	
2	EC	202	Principles of Microeconomics	
2	EC	350	Money and Credit	
2	ENG	313	Business Writing	
2	FI	330	Corporate Finance	
2	FR	101	Elementary French	
2	FR	102	Elementary French	
2	GER	102	Elementary German	
2	HPRD	101	Beginning Leisure Life Skills	
2	INS	350	Introduction to Risk Management & Insurance	
2	LGLS	300	Legal Environment of Business	
2	MATH	211	Calculus of One Variable	
2	MATH	216	Intermediate Calculus	
2	MATH	447	Methods of Statistical Inference I	
2	MATH	448	Methods of Statistical Inference II	
2	MK	301	Basic Marketing	
2	PHYS	237	Mechanics	
2	PHYS	238	Electricity & Magnetism	
2	PHYS	239	Heat, Sound, Light, Modern Physics	*
2	POLS	101	Introduction to American Government	
2	PSY	423	Psychology of Work	
2	RE	301	Real Estate Principles	
2	RTP	25	Writing Review for the Regent's Exam	
2	SOC	201	Introduction to Sociology	
2	SOC	316	Sex Roles in Modern Society	
2	TH	304	History of World Theatre	

"*" following a course indicates a course misclassified accord to the discriminant analysis of course clusters.

Figure 6-13c. Cluster 3: High positive mean residuals on Quantitative Comparisons (QC) and Analytic Reasoning (ARE); high negative mean residuals on Reading Comprehension (RD).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
3	AC	301	Basic Accounting Systems	
3	AC	401	Financial Accounting I	
3	AC	402	Financial Accounting II	
3	AC	420	Managerial Accounting	
3	APPF	100	Applied Music-Introductory	*
3	BED	456	Beginning Typewriting	
3	BED	471	Introduction to Word Processing	
3	CIS	303	Assembly Language Programming	
3	FED	310	Educational Psychology	*
3	LGLS	405	Comprehensive Business Law	
3	MATH	220	Discrete Mathematics	
3	MK	434	Sales Management	
3	MUS	320	Music for Elementary Classroom Teacher	
3	RMI	350	Introduction to Risk Management & Insurance	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13d. Cluster 4: High positive mean residuals on Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
4	AC	450	Federal Income Taxation I	
4	BED	436	Business Communications	*
4	CIS	210	Intro to Computer-Based Information Systems Development	*
4	DM	122	Decision Mathematics II	*
4	GER	201	Intermediate German	
4	GER	202	Intermediate German	
4	IS	410	Intro to Data Structures & Algorithmic Process	
4	MGT	450	Entrepreneurship & New Venture Management	
4	UL	301	Introduction to Urban Life	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13e. Cluster 5: High positive mean residuals on Antonyms (ANT); high negative mean residuals on Analytic Reasoning (ARE) and Reading Comprehension (RD).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATION
5	AC	460	Auditing I/Auditing & Controls	*
5	ANTH	100	Introduction to Physical Anthropology	
5	APFL	200	Applied Music-Lower Level	
5	ART	101	Drawing I	
5	ART	102	Drawing II	
5	ART	103	Two Dimensional Design	
5	ART	104	Three Dimensional Design	
5	ART	105	Color	
5	ART	178	Survey of Art I	
5	ART	179	Survey of Art II	
5	BA	309	Introduction to International Business	
5	BIO	111	Human Anatomy & Physiology	
5	BIO	112	Human Anatomy & Physiology	
5	BIO	324	Human Physiology	
5	BIO	325	Human Physiology Lab	
5	CHEM	102	Organic & Biochemistry Survey	
5	CHEM	111	Chemical Principles I	
5	CHEM	113	Chemical Principles III	
5	CHEM	116	Chemistry Lab I	
5	DS	81	Developmental English I	
5	DS	90	Developmental Mathematics I	*
5	ENG	212	Advanced Expository Writing	
5	FILM	370	History of the Motion Picture	
5	GEOG	103	Physical Geography I	
5	GEOG	104	Physical Geography II	
5	HRTA	310	HRT Personnel Management	
5	HRTA	330	HRT Law	
5	HRTA	350	Travel & Tourism	*
5	IS	201	Introduction to Data Processing	
5	JOUR	101	Reporting I: Basic Journalism	
5	MK	433	Principles of Selling	
5	MUS	105	Woodwind Laboratory	
5	MUS	193	Introduction to Music	
5	PHYS	101	Introductory Physics	
5	PHYS	210	Physics for the Visual Arts	
5	POLS	320	Comparative Politics	*
5	PSY	204	Introduction to Applied Psychology	*
5	RTP	25	A Writing Review for the Regent's Exam	
5	SPAN	101	Elementary Spanish	
5	TH	410	Contemporary Theatre	*

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13f. Cluster 6: High positive mean residuals on Analtyic Reasoning (ARE); high negative mean residuals on Antonyms (ANT) and Reading Comprehension (RD).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
6	.PTP	200	Not available.	
6	APTP	300	Not available.	
6	APVC	200	Applied Music-Lower Level	
6	APVC	300	Applied Music-Concentration	
6	ART	466	Advanced Interior Design	
6	BA	201	Introduction to Management Information Systems	
6	CJ	490	Seminar on Criminal Justice Problems	
6	DM	310	Decision Mathematics III	
6	DSC	122	Survey of Calculus	
6	DSC	310	Introduction to Business Statistics	
6	DSC	312	General Modeling Techniques	
6	ENG	111	Composition I	
6	ENG	112	Composition II	
6	FED	305	Human Growth & Development	
6	GEOL	102	Historical Geology	
6	HPRD	345	Physical Education for Elementary Teachers	
6	IB	309	Introduction to International Business	
6	LSM	436	Selection & Utilization of Education Media	*
6	MATH	126	Analytic Geometry & Trigonometry	*
6	MGT	430	Introduction to Personnel & Industrial Relations	*
6	MGT	435	Organization Theory & Practice	
6	MGT	436	Personnel Selection & Development	*
6	MGT	437	Introduction to Organizational Communication	
6	MGT	439	Compensation Administration	
6	MGT	470	Operations Management	*
6	MK	410	Buyer Behavior	
6	MK	420	Marketing Research	
6	MK	430	Advertising	
6	MK	431	Advertising Campaigns	*
6	MK	451	Industrial Marketing	
6	MK	490	Marketing Problems	
6	MUS	102	Voice Laboratory	
6	MUS	103	Not available.	
6	MUS	106	Instrumental Ensemble	
6	MUS	108	Choral Ensemble	
6	MUS	110	Concert Attendance	
6	MUS	126	Percussion Methods	
6	MUS	144	Musicianship	
6	MUS	145	Musicianship	
6	MUS	161	Music Survey	
6	MUS	191	Class Introduction to Piano	
6	MUS	244	Musicianship	
6	MUS	245	Musicianship	
6	MUS	246	Musicianship	
6	PHIL	241	Introduction to Logic	
6	PSY	101	Contemporary Psychology	
6	PSY	203	Intro to Basic Psychological Process	*
6	PSY	301	Psychological Statistics	

6	SPCH	101	Voice & Articulation	
6	SPE	401	Exceptional Children & Youth	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13g. Cluster 7: High positive mean residuals on Analytic Reasoning (ARE) and Quantitative Comparisons (QC); high negative mean residuals on Antonyms (ANT).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
7	ART	350	Photography I	
7	CJ	371	Constitutional Law	
7	HIST	113	U.S. History 1492-Present	
7	HIST	476	History of the American City	
7	JOUR	201	Reporting II: News Gathering/Reporting	
7	JOUR	302	Mass Media & Society	
7	JOUR	304	300 Years of American Journalism	
7	JOUR	306	Journalism Law & Ethics	
7	JOUR	410	Copyreading	
7	JOUR	421	Business & Industrial Journalism	
7	JOUR	450	Public Relations	
7	JOUR	454	Cases & Problems in Public Relations	
7	JOUR	498	Internship	
7	PSY	303	Principles/Methods of Psychological Investigation	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13h. Cluster 8: High negative mean residuals on Analytic Reasoning (ARE) and Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
8	BIO	141	Principles of Biology	*
8	BIO	142	Organisms & Their Environment	*
8	MH	310	Personal Growth & Self Development	
8	PSY	416	Theories of Personality	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13i. Cluster 9. High positive mean residuals on Reading Comprehension (RD), Analytic Reasoning (ARE), and Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
9	BIO	382	Plant Biology	
9	BIO	384	Animal Biology	
9	BIO	390	Genetics	
9	CHEM	112	Chemical Principles II	
9	CHEM	117	Chemistry Lab II	
9	CHEM	118	Chemistry Lab III	
9	CHEM	240	Organic Chemistry I	
9	CHEM	241	Organic Chemistry II	
9	CHEM	242	Organic Chemistry III	
9	CHEM	460	Biochemistry I	
9	ENG	315	Introduction to Creative Writing	*
9	MATH	212	Calculus of One Variable	*
9	MATH	215	Multi-variable Calculus	
9	MATH	335	Matrix Theory	
9	MATH	435	Linear Algebra	
9	MATH	451	Mathematical Statistics I	
9	MATH	461	Advanced Calculus I	
9	MATH	462	Advanced Calculus II	
9	MGT	350	Management Concepts Theory & Practice	*

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13j. Cluster 10. High negative mean residuals on Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
10	CHEM	101	General Chemistry	
10	DS	50	Personal & Academic Development Seminar	*
10	DS	71	Developmental Reading II	*
10	ENG	385	Southern Literature	
10	MATH	107	Elementary Statistics I	*
10	MATH	122	Not available.	
10	MH	498	Not available.	
10	PSY	105	Foundations of Psychology	
10	PSY	202	Introduction to Social/Developmental Psychology	
10	PSY	356	Leadership & Group Dynamics	
10	PSY	358	Psychology of Human Potential	
10	PSY	404	Child Development	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13k. Cluster 11. High positive mean residuals on Analytic Reasoning (ARE) and Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
11	CJ	301	Introduction to Criminal Justice	
11	CJ	311	The American Police System	
11	CJ	321	Juvenile Delinquency	
11	CJ	331	Corrections	
11	CJ	370	Courts & Basic Criminal Procedure	
11	CJ	411	Principles of Investigation	
11	CJ	475	Criminal Law	
11	CJ	494	Criminal Justice Field Instruction	
11	DS	92	Introduction to Algebra	
11	ENG	201	European Literature I	*
11	GEOG	101	Introduction to Human Geography	*
11	US	301	Introduction to Urban Studies	
11	US	302	Methods of Urban Research	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13l. Cluster 12. High positive mean residuals on Reading Comprehension (RD).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
12	DM	312	Not available.	*
12	ENG	113	Advanced Composition	*
12	ENG	211	Survey of English Literature I	
12	ENG	409	History of the English Language	
12	ENG	435	Shakespeare: Tragedies	
12	GEOG	350	Urban Geography	
12	GER	101	Elementary German	*
12	MATH	105	Math for Liberal Arts	
12	MATH	125	Not available.	
12	PHIL	302	History of Western Philosophy II	*
12	PHYS	102	Introductory Physics	*
12	POLS	414	Urban Politics	
12	POLS	462	Not available.	
12	PSY	201	General Psychology	
12	PSY	314	Abnormal Psychology	*
12	RUS	101	Elementary Russian	
12	RUS	102	Elementary Russian	
12	RUS	201	Intermediate Russian	
12	SPCH	445	Nonverbal Communication	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

Figure 6-13m. Cluster 13. High negative mean residuals on Analytic Reasoning (ARE) and Quantitative Comparisons (QC).

CLUSTER	DEPT	NUM	DESCRIPTION	MISCLASSIFICATIONS
13	MATH	104	College Algebra	*
13	MGT	401	Introduction to Organizational Behavior	*
13	SOC	308	Sociology of the Family	

"*" following a course indicates a course misclassified according to the discriminant analysis of course clusters.

VII. Summary and Conclusion

This report concentrated on an examination of transcripts and assessment test scores from the combined native sample of graduating seniors at Georgia State University in the 1986-87 and 1987-88 academic years. The main purpose of this project was to determine if enrollment in different patterns of coursework were associated with gains in the general learned abilities of undergraduate students. The answer to this question was consistently "yes". Roughly 8.1 of 10 courses analyzed were accurately grouped according to differential effects in the general learned abilities of students. Taking different patterns of coursework did lead to different types and levels of development as measured by the nine item-types of the GRE General Test.

Several consistent findings emerged from the analysis of coursework clusters. First, the development of general learned abilities did not have an exact one-to-one relationship with departmental categories. All quantitative reasoning development did not occur exclusively in Mathematics-related courses, for example. Consequently, simple counts of the number of credits or courses a student has taken in a particular subject may not be a reliable proxy of general learning in the attendant subject area. Quantitative skills may be developed in a variety of courses such as accounting, management, and computer information systems. Second, the development of general learned abilities was not confined to the lower division. While there is clearly a difference between general education and general learning (as measured by the GRE), general education requirements should be re-examined in light of student improvement in general learned abilities. Coursework taken by students who showed significant gains should be examined, evaluated and incorporated into the general education sequence of the college. Third, beyond the college catalog, there was little formal monitoring and description of the curriculum in terms of general learned abilities at the college-wide or university-wide level. Colleges should regularly monitor the number of credits and courses in their curriculum. Without this baseline data, the extent to which students share a common learning experience at a college cannot be readily determined.

The relationships established through the cluster analytic model were associational, not causal. Once a set of courses has been linked to improvement in a specific learned ability, a targeted investigation can be launched to determine the commonalities of teaching-learning environment, of student and faculty expectations of performance, of the specific abilities of the students who enrolled in the classes. But regardless of what hypotheses are generated about why this coursework/programs are associated with gains in learned abilities, one can state with confidence that students who enrolled in this coursework demonstrated gains on a specific type of learned ability.

Coursework patterns with negative means have limited meaning. A negative mean of residuals on a coursework cluster does not necessarily mean actual decline in general learning, only decline about the group tested. Regression automatically defines half the residuals as negative. The mean performance of the group tested is the basis upon which the individuals' GRE item-type scores are predicted from the corresponding SAT scores. By definition, half the group falls below the mean, half is above it. Therefore, those with negative means may have gained in general learned abilities. The negative sign shows that their gain fell below the mean of students in the sample. Declines in general learned abilities are relative to the sample group and may or may not represent actual declines in abilities.

Gains in student learned ability may be attributable to learning outside the classroom. Programs in this research are the settings for analysis.

Comparable analysis could be conducted according to student residential groupings. It is known, for example, that on many campuses the academic performance of students in one fraternity or sorority may be consistently above the average for that college, while students living at another Greek residence setting may be well below the campus norms for academic performance. Does living in a fraternity or sorority cause higher or lower academic performance? Not necessarily. These are selective and self-selected residential situations; the relationship with academic performance is associational.

The coursework patterns identified in this research include general education, major, minor and electives. No a priori distinction was made according to these categories prior to analysis of the data. A physical education course in Tennis may be associated with improved learning in Regular Mathematics. This does not mean that enrolling in Tennis causes improved abilities in Regular Mathematics. What it does mean is that students who enrolled in this course tended to improve in this learned ability. Why? The cluster analytic model does not tell us why. Its purpose is to sort through the hundreds or thousands of courses in the college curriculum. The model points out those coursework patterns taken by students who improve in general learned abilities.

The cluster analytic model of analysis is admittedly complex. It would be simpler to calculate residuals on one item-type, such as Regular Mathematics, and then to rank order all coursework according to the mean residuals of students in each course. This would give a picture of each course according to one measure of general learning. However, it would not give an idea of the role of that strength of that ability or measure relative to other measures of general learning used in the assessment. The discriminant analysis shows the role of various types and measures of general learning relative to the coursework that students take in college.

Where does this leave us? First, we acknowledge that the cluster analytic model performed well with the combined sample at Georgia State University. It sorted and classified programs according to a given set of measures of general learned abilities. Second, some program patterns identified made sense. Some programs involving mathematics were associated with gains in mathematics abilities.

If all student coursework was distributed randomly throughout the curriculum, so too would be their test score residuals. A non-random distribution of residuals implies that specific coursework makes a difference in the development of general learned abilities. Only those courses selected by students showing improvement above the mean for their group should have positive mean course residuals. This research affirmed the differential coursework hypothesis. This research also affirmed the person environment fit hypothesis (Pascarella, 1985).

Student need not choose from several hundred or several thousand courses to have an effective education. The existence of a multitude of courses may be a healthy sign. It may show that colleges and universities accurately mirror the explosion and complexity of knowledge in the last decade of the twentieth century. Such complexity need not impair the development of general learned abilities in undergraduates.

Yet, this research suggests that many students do not make wise course selections. At least they don't make smart choices in relation to those general learned abilities tested by the most commonly recognized post-baccalaureate test of general learning. The mean residuals of most courses taken by students in common with other students of the same cohort was near zero. This means that the general effect of coursework on student learning was randomly distributed across the curriculum. Perhaps only one-third of coursework taken in common (5 or more students) could be found to have a positive relationship with general learning as measured. This rate of return can be improved by developing more discrete arrays of coursework applicable to general education requirements and by organizing and informing the student academic advising process so that students may choose among coursework aligned with their abilities and prior learning. To that end, the cluster analytic model for identifying the differential effect of coursework holds promise to revising and enhancing the conditions for excellence in undergraduate general learning.

It is commonly assumed that the general curriculum leads to gains in general learning and the major, minor and elective curriculum leads to gains in subject area learning. If such were the case, then the positive residuals on measures of general learning should occur with the courses which students hold in common. Also, negative mean course residuals should be primarily distributed among courses which students did not hold in common.

We know a great deal about what colleges say should be the goals and standards for a baccalaureate degree. The DCP research suggests that much future research is needed to determine what curricular patterns and trends consistently produce the gains in general learning that institutions seek to impart to their students. The challenge of understanding the specific impact of coursework on the learning of students has just begun.

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